SAE Journal

AUGUST 1957

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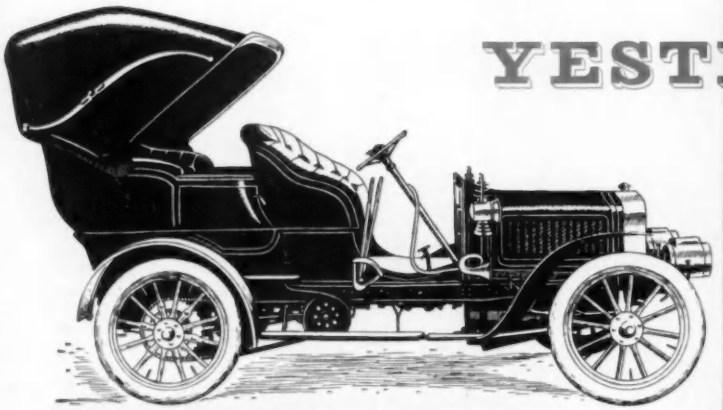

YESTERDAY...

when compression ratios were 3 to 1, any good oil ring would do...as in this jazzy 1905 Pope-Toledo Touring Car. Known as Type VIII, fitted with a Victoria Top, it was advertised as being "tested to do a mile in one minute flat before leaving the factory."

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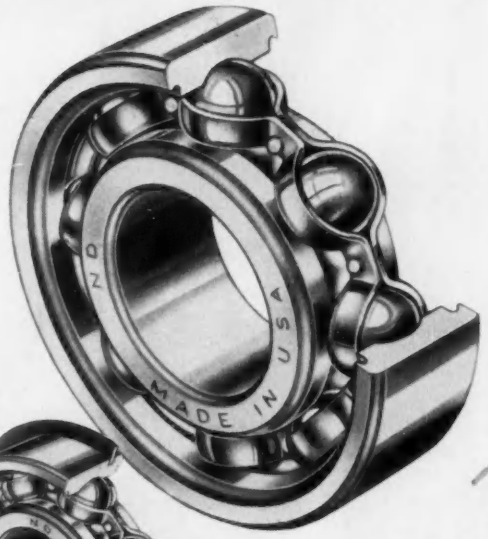
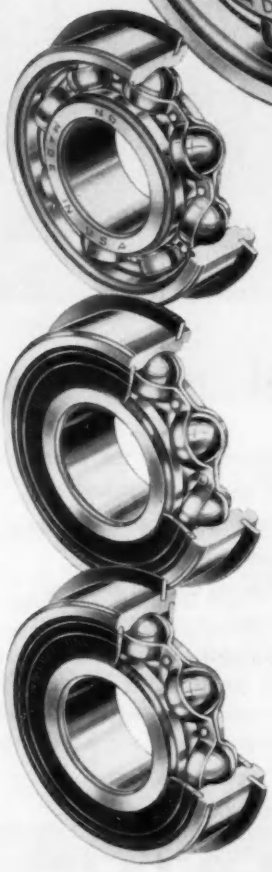
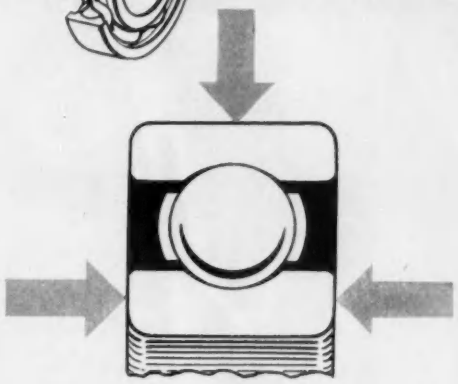
FACTS

about

NEW DEPARTURE BALL BEARINGS







The Word *Versatile*

Fits Like A Glove!

Fits because—this basic New Departure ball bearing, more widely used than any other antifriction type, does much more than carry RADIAL loads—it locates the shaft it supports against THRUST LOADS FROM BOTH DIRECTIONS equally well!

Fits because—with a simple snap ring added, it does away with inside housing shoulders, simplifying mounting and cutting machining costs!

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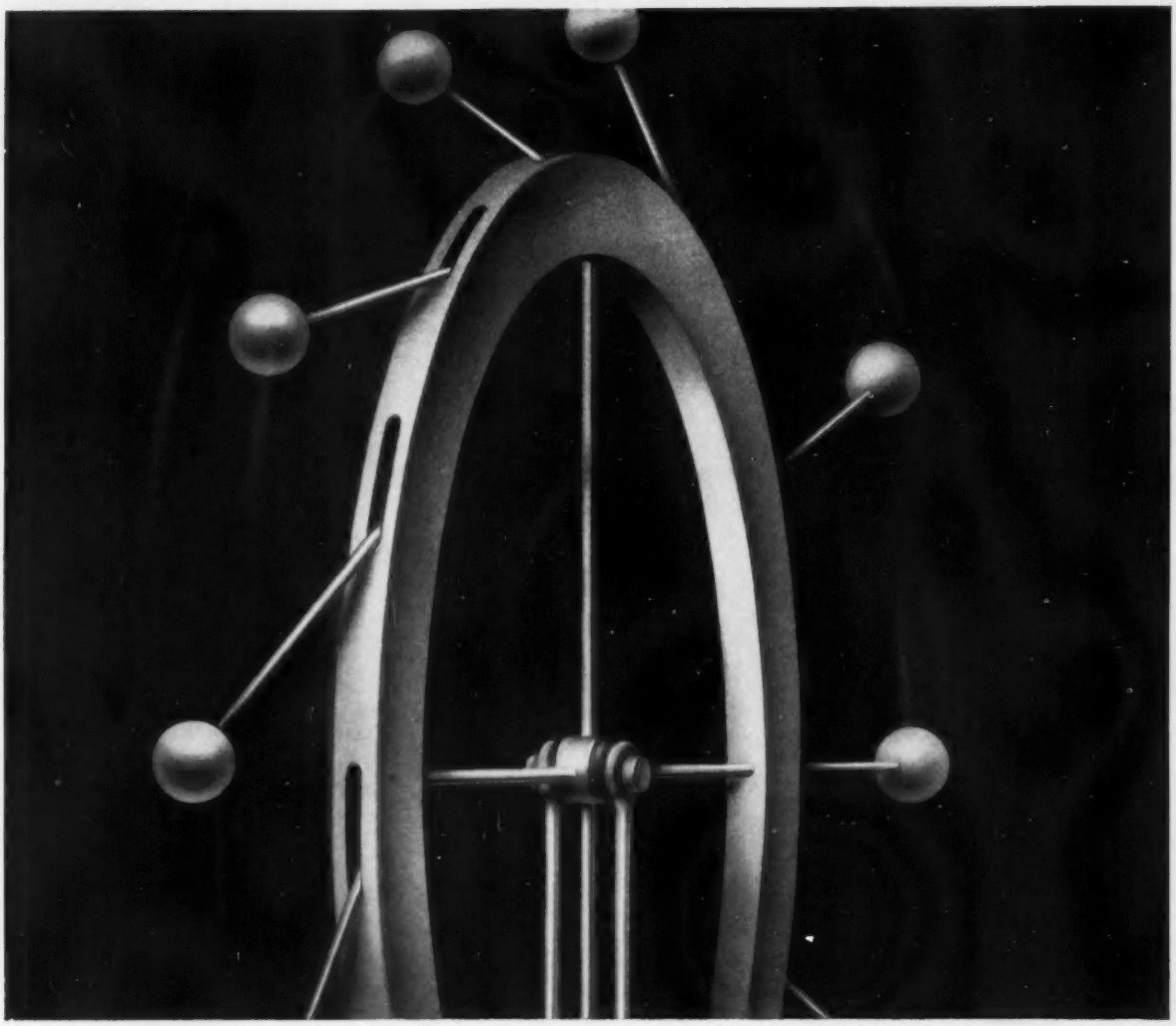

what ever happened to perpetual motion?

Nobody's ever solved it, and maybe they never will. Complete elimination of friction and wear are seemingly impossible obstacles.

But industry *has* developed machinery that will virtually run forever. The hermetically sealed unit in your refrigerator, for instance. And even equipment that is not sealed – provided that wear-producing foreign elements can be kept out.

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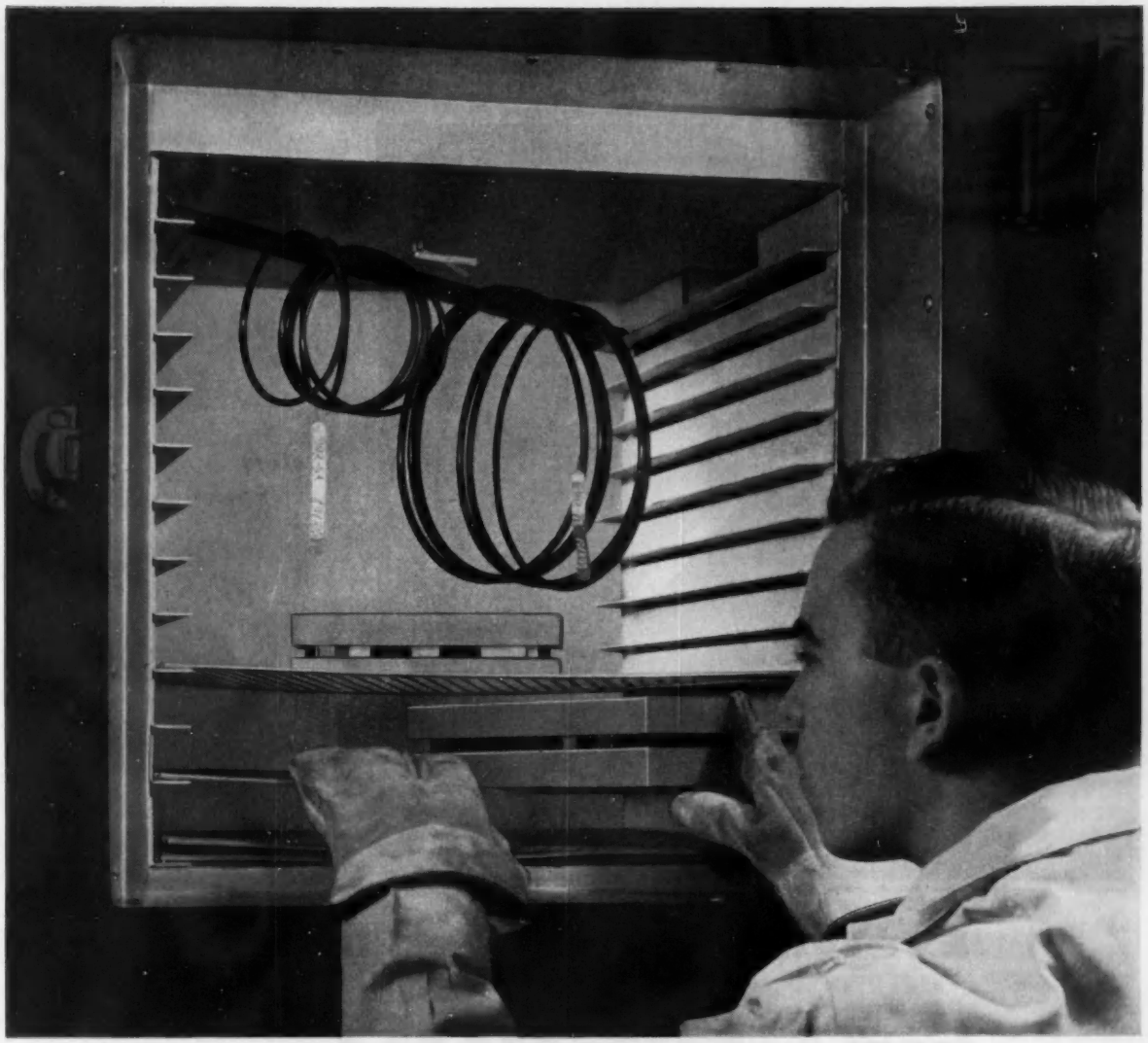

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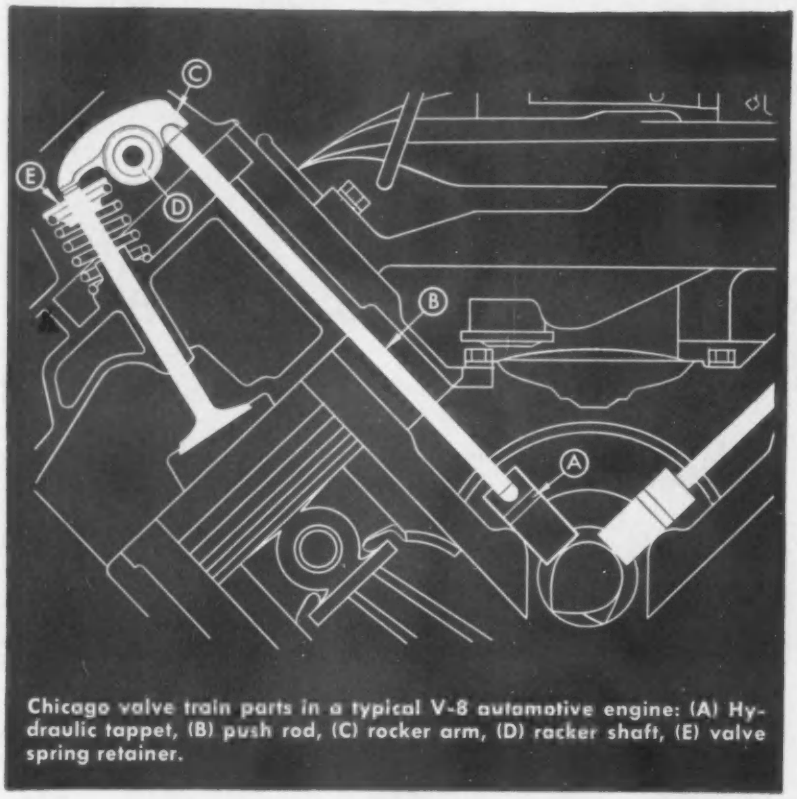


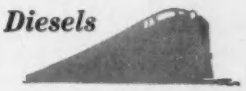
Chicago valve train parts in a typical V-8 automotive engine: (A) Hydraulic tappet, (B) push rod, (C) rocker arm, (D) rocker shaft, (E) valve spring retainer.

Passenger cars

Trucks

Tractors

Diesels



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Here at Chicago you'll find a single source for everything you need in valve gear. These specialized facilities are solving problems and saving money for leading engine manufacturers . . . and can do the same for you.

Design and Engineering—at Chicago you'll find valve gear engineering experience in depth . . . men who understand your problems and will work with your engineering staff in designing cam shafts and complete valve gear assemblies for any type of engine.

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Tru-Seal is the only practical, economical method yet devised to seal a multiple-piece rim. It's just one of the many advances resulting from Goodyear's matchless experience in building rims for every type of vehicle. When you specify Goodyear rims you get:

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New Tru-Seal Rims—for sizes 12:00 and up, including all earth-mover and grader sizes. This rim is similar to multiple-piece rims now in use—PLUS airtight Tru-Seal rubber ring which compresses into sealing groove when tire is mounted.

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Tru-Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

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Young

cools the heart of this tough baby!

Mobile anti-tank weapon relies on Young's super-strength radiators to cool its 6-cylinder 145 hp engine

Only equipment proved by test to give the best service, longest life, could be incorporated in the M 50 vehicle (Ontos) anti-tank weapon. Vibration and high engine compartment temperature created by extreme operating conditions require the most rugged and most efficient cooling systems.

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- Side seat shields
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Nothing is older than last year's automobile model. In an industry where new advances are made annually, better materials are continually required for improved engineering and design.

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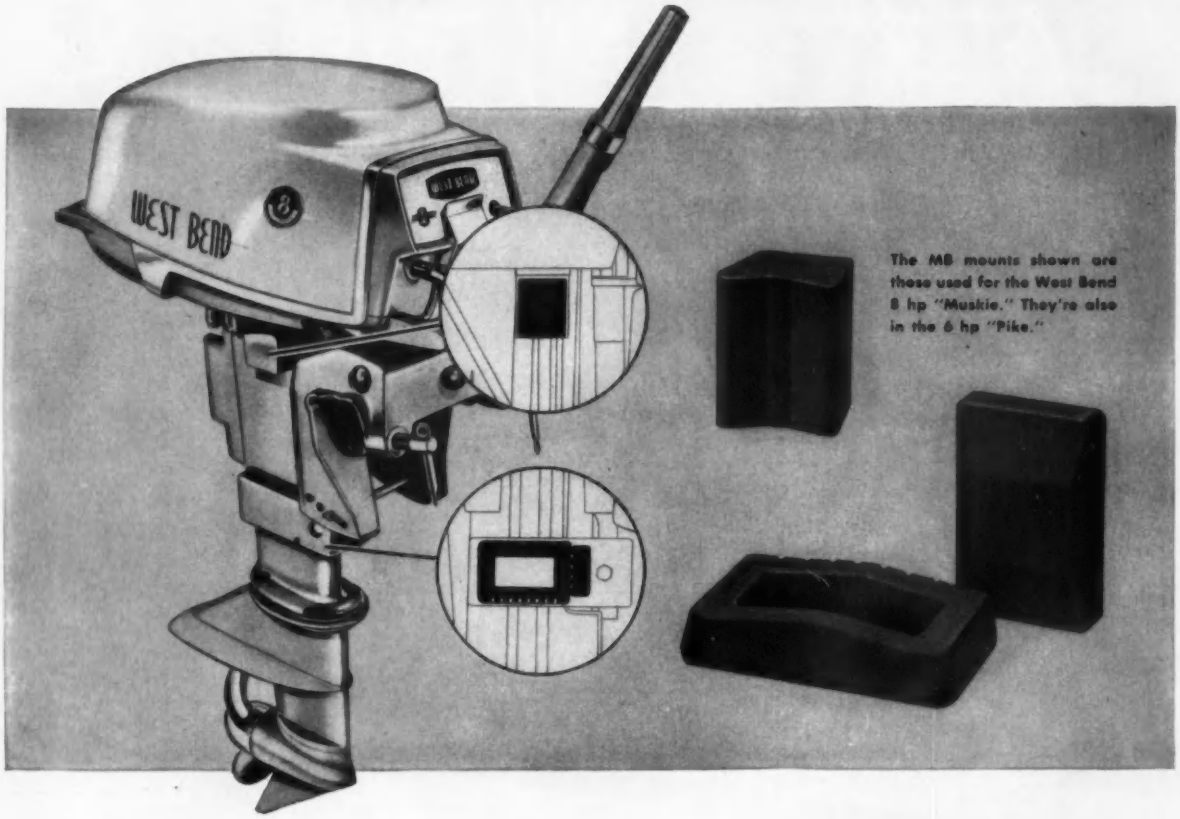
this *smooth power* floats on MB mounts



WEST BEND outboard motors for 1957 feature new colors, wider range of ratings. But one thing doesn't change: Their freedom from annoying vibration. Special MB vibration mountings, as they have for years, isolate motor from boat.

Satisfactory isolation of outboards can be difficult to achieve. Modes of motion are rougher; underwater service conditions are hardly ideal; and the location of suspension points is relatively restricted. Specially engineered, all-neoprene MB mounts overcome these problems...taming torque from engine, and cushioning impulse from propeller.

MB concentrates on mounts which start where ordinary units have to give up. While *standard* units are available, MB mounts are actually in the *special performance* class. Perhaps we can work out a modification of one to solve *your* troublesome vibration problem. Send for Bulletin 616A.

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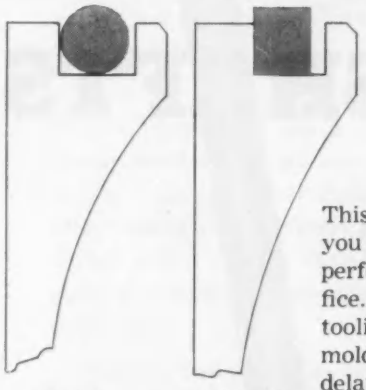
can save you money in *STATIC* or *MOVING* seal applications



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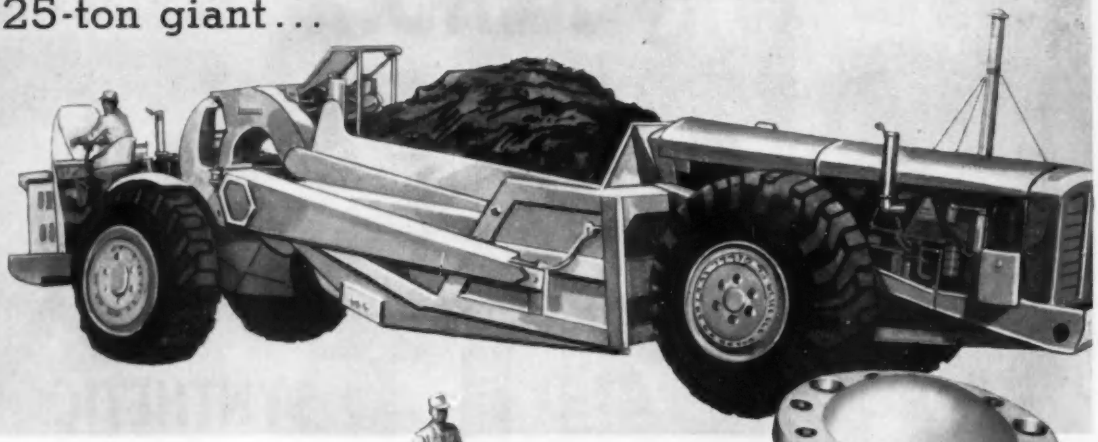
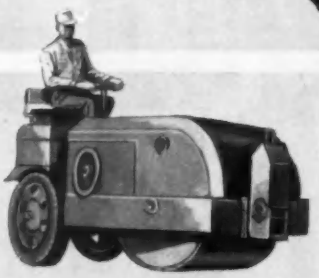


...or 1½-ton roller



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Whether you make a small roller . . . or a 25-ton road scraper, U.S. Axle can design and build axle shafts to your exact requirements. U.S. Axle is the manufacturer of the world's most complete line of replacement shafts for cars, trucks and buses. Every U.S. Axle Shaft is precision made from finest alloy steels to rigid specifications to assure a perfect fit. Every one is shot-peened for extra toughness and long-lasting, dependable performance. Every one is guaranteed to enhance your product's reputation for fine quality.

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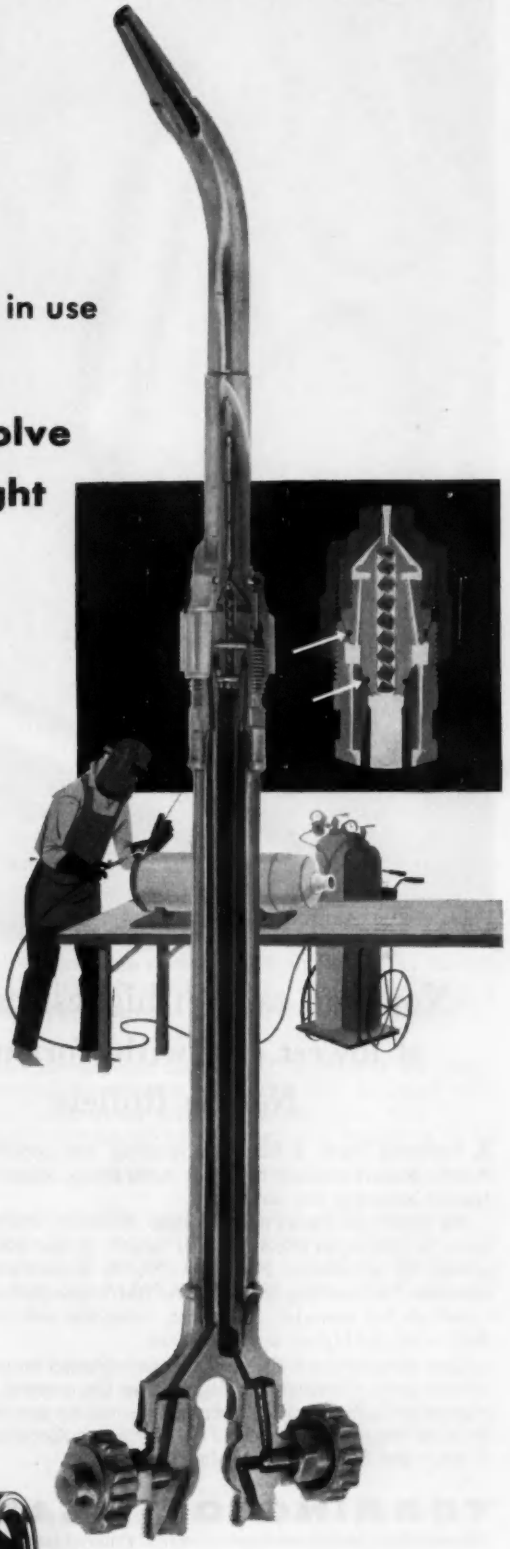
Ozone deterioration

Continuing stress

Gas leakage

Rough handling in use

New National Hypalon O-rings solve these problems; insure a hand-tight gas seal in Victor Torches



As static seals, commercial Buna N O-rings performed satisfactorily in Victor welding torches — *when the rings were new.*

However, ordinary O-rings age fast in welding torches. They receive rough treatment when welders change nozzles; nozzles are often dropped on the ground to lie there until needed again. Severe ozone deterioration is experienced. Continuing stress, although mild, impairs O-ring elasticity. Rings on welding nozzles are sometimes subjected to long shelf life.

National Seal engineers developed a new O-ring compound, National Hypalon L-11, which not only withstands rough handling, ozone deterioration and stress but exhibits many times the shelf life of Buna N compounds previously used. Today, National Hypalon is standard at Victor.

Special compounding to meet unusual conditions is a basic part of National's complete O-ring engineering service — service available from National Field Engineers in major cities nationwide.

NATIONAL SEAL
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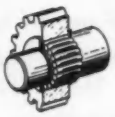
Full complement of small diameter rollers insures maximum number of contact lines in load zone for high radial capacity in minimum space.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Torrington Needle Rollers allow largest possible shaft diameters.

Carefully hardened, ground and lapped high carbon chrome steel makes each Torrington Needle Roller a precision part for long life performance.

Close tolerances are assured by stringent quality controls. Standard OD tolerance is .0002", but Torrington Needle Rollers can be supplied with tolerance of .00005". Tolerance on length depends on end shape.

Fine finish reduces friction to a minimum. Torrington Needle Rollers are usually polished to 4-6 rms, but finishes as fine as 1-3 are available on special order.

Now you can get highest capacity at lowest cost with Torrington Needle Rollers

A hardened shaft, a hardened housing, and precision Torrington Needle Rollers provide the most economical, highest capacity antifriction assembly you can obtain.

Six roller end shapes permit design flexibility whether the requirement be maximum effective roller length, proper fillet clearances or greater lip retainment. Torrington Needle Rollers are available in a complete line meeting SAE and AFBMA specifications. Torrington standards for material, heat treat, tolerance and finish of Needle Rollers are the highest in the industry.

Operating results with Needle Rollers depend on careful design of mating parts. Torrington's Engineering Department, with extensive experience in Needle Roller application, will be glad to give you technical advice on your needs. *The Torrington Company*, Torrington, Conn.—and South Bend 21, Ind.

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For the Sake of Argument

Fragility . . .

By Norman G. Shidle

Fragility poses hard problems to those who must handle it—in materials or ideas or people.

The beauty, lightness, or style of a material may be just what is needed . . . if the designer can create an environment in which fragility is no handicap. "Whether it be a strong wire rope or a slender and delicate thread that holds the bird, it matters not, if it really holds it fast; for, until the thread is broken, the bird cannot fly."

Some ideas are capable of living if "screened" by judgments of normal harshness. But they may blossom with inspiration if examined gently and nurtured with sympathy. Take silence, for example. To name it is to break it.

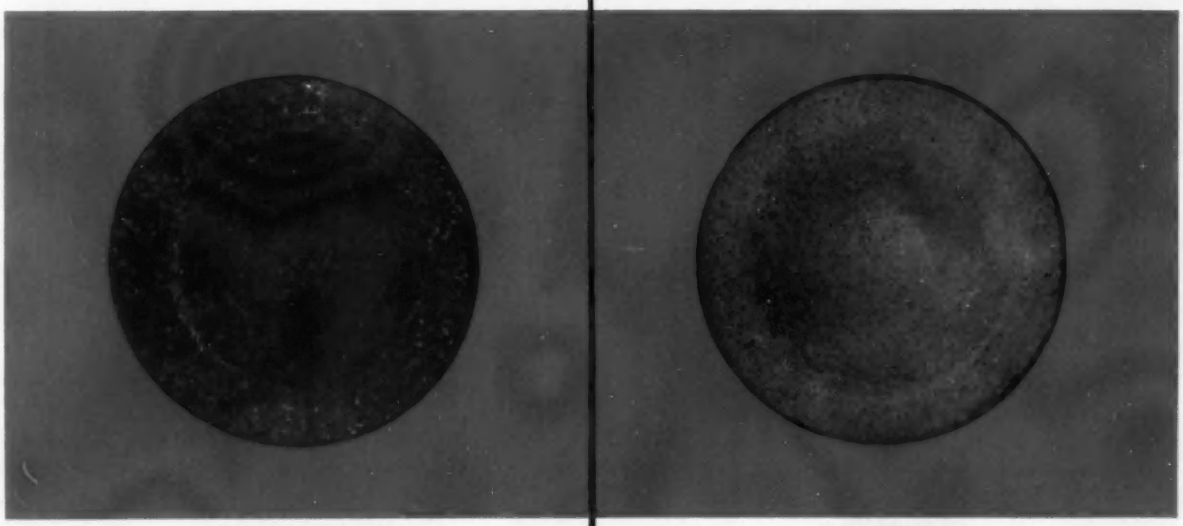
Most of us are pretty heavy-handed—and we know it. So we tend to play safe when faced with fragility. To avoid destroying it, we try never to touch it. We let lie its unique potentials for good, lest the weight of our touch destroy them.

And when fragile ideas come from emotionally fragile associates, we are all too likely to turn and run. Result: our operations go forward sans elements which might have transformed "all right to good" . . . or "good to best."

Application of a fragile material to its proper function in design takes courage as well as imagination. To pick up a fragile idea—especially from a sensitive person—takes even more courage . . . and at least as much imagination.

The EATON Process of Aluminizing Exhaust Valve Heads PREVENTS PRE-IGNITION

CAUSED BY INCANDESCENT SCALE



NOT ALUMINIZED
Note Scale which Promotes Pre-ignition

ALUMINIZED
Absence of Harmful Scale Prevents Pre-ignition

Conventional exhaust valve steels, run at high temperatures, tend to corrode and scale, promoting damaging pre-ignition. This condition can be overcome by the use of expensive high-alloy materials. However, there is a simple and less expensive solution to the problem. By applying the Eaton aluminizing process to conventional exhaust valve steel, resistance to corrosion and scaling can be increased tremendously, thereby eliminating a condition which can be a major cause of pre-ignition.

Inlet valves conditioned by the Eaton aluminizing process also are contributing to the increased efficiency, dependability and service life of engines.

Our Valve Division engineers will be glad to discuss the application of Eaton aluminized valves to your engines. Send for illustrated literature.

Aluminizing of Inlet Valve Seat-Face Prevents Oxidation

After aluminizing by the Eaton process, this plain carbon steel valve was placed in an air atmosphere furnace at 2000°F. for 16 hours. Gross oxidation of the base steel resulted. The aluminized seat-face and margin areas were unaffected.

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Bendix PRODUCTS DIVISION **South Bend** IND.

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AVIATION CORPORATION

Because there's need for greater speed and range

The Hunt is on for New Sources of Propulsion Energy

Based on report by **Hugh Harvey,** Shell Oil Co.
to the Executive Committee for the April 1958 SAE National Aeronautic Meeting

ANYTHING that flies, be it a bee, an eagle, a DC-7, or a guided missile, has to expend energy continuously. The rate of expenditure is a function of the speed; total expenditure, on the other hand, is a function of duration or range.

Aircraft and missiles—which, by the way, seem to be becoming one and the same thing—have a limitation on their performance based on the amount of energy, in the form of fuel, that they can carry. Greater speed and greater range are required for the future, and for these reasons the hunt for new sources of energy is on. (By contrast, our present aerial strategy is based on in-flight refueling with conventional fuels, an operation that is wholly incompatible with the concept of supersonic aerial defense.)

For over half a century petroleum has been the source of energy for the airplane. As a convenient, clean, and economic form of packaged energy, it has had no peer, and its versatility has made it the ideal fuel for all types of engines, spark ignition, compression ignition, turbine, and ramjet. It will be difficult, if not impossible, to find any fuel that can compete with it on a dollar-per-pound basis.

But aircraft and missile designers are looking for fuels that surpass present ones on an energy-per-pound and energy-per-gallon basis. Sometimes the vehicle they are designing is weight limited—that is, it has to sacrifice payload in favor of a given weight of fuel if it is to accomplish the mission for which it was designed—and sometimes it is volume limited, a common occurrence with high-speed weapons with very thin wings. As a first approximation it is safe to assume that the aircraft is both space and weight limited. Therefore, it's desirable —though not always possible—to have high Btu's both per unit weight and per unit volume.

As a source of energy for the increased speed and and range, designers of military weapons and weapons systems are investigating various chemical compounds. These compounds may be used as fuels in air-breathing engines or as propellants for rocket-type powerplants. Cost, for the application under consideration, is far from the determining factor. For example, if a weapon can be developed that can, because of its speed and range, penetrate with certainty an enemy's defenses, the cost of the fuel will be immaterial.

Any assessment of potential fuels begins with a comparison of their heat release per unit weight, and such a comparison is shown in Table 1. As would be expected, hydrogen is by far and away the outstanding performer, having almost three times as much available energy per pound of weight as kerosene or gasoline. This is not surprising, particularly to those of us familiar with nineteenth century science fiction whose writers were always choosing hydrogen to propel super warships and submarines. Unfortunately, hydrogen presents what appear to be insuperable handling problems. It has to be compressed if it is to be stored and transported as a fuel and, as a consequence, equipment for containing high pressures has to be employed.

Even if a practical solution to the mechanical difficulties could be worked out, the results would be disappointing because the heat content per unit volume of hydrogen is very low. At 2000 psia and 60F, the density of hydrogen is 0.093 lb per gal and the heat content is 4780 Btu per gal. A rough calculation reveals that to use hydrogen as the fuel for, say, a DC-7C on the transatlantic run would require 120,000 gal, or a fuel capacity about 17 times larger than is available. Add to this impossible sit-

uation the weight of the pressure vessels to contain the fuel, and it becomes obvious why hydrogen can receive little consideration as a high-energy fuel.

But it would be a grave mistake to discard hydrogen entirely because it is hydrogen that is to a large degree responsible for the performance of petroleum fuels. Aviation gasoline is, for example, a mixture of many combinations of hydrogen and carbon. Taking a typical eight-carbon-atom molecule, we can calculate that 40% of its energy can be attributed to its hydrogen content and 60% to the carbon it contains. But the carbon contributes 84% of the weight of the fuel—a disproportionate amount.

One approach to the obtaining of high-energy fuels would be to replace the carbon atoms in the hydrocarbon molecule with an element having a higher heat release per unit weight than carbon. Referring to Table 1, it would seem obvious to select beryllium, an alkaline earth sometimes known as glucinium, which has, next to hydrogen, the highest Btu's per pound of all the elements. Unfortunately, it does not readily combine with hydrogen and, furthermore, it is quite scarce and it forms compounds that are toxic. On the other hand, boron, a nonmetal, and lithium, an alkali metal, form hydrogen compounds, or hydrides, that are of interest to this discussion. Both are, as a matter of fact, under investigation as components of new fuels.

An interesting way of considering the relative merits of various fuels is to rate them according to performance index. This is a ratio that relates the available energy of a fuel per pound to the available energy per gallon and expresses this relationship in terms of the performance of kerosene. Here we are assuming that with a given aircraft both weight-lifting capacity and space for carrying fuel are equally scarce. This is, admittedly, a gross approximation, though there can be circumstances where it is applicable. The performance index can be expressed as follows:

$$\text{P.I.} = \frac{(\text{Btu/lb})\ \ (\text{Btu/gal})}{K}$$

where K is the product of the Btu's per pound and the Btu's per gallon for kerosene, or 170×10^8.

The bar graph opposite shows the relative performance indices of various materials that are or can be used as fuels. It is immediately apparent that, on this basis of evaluation, beryllium and boron are outstanding performers. However, as mentioned previously, there are many reasons why beryllium does not appear suitable as a high-energy fuel. Boron, on the other hand, presents fewer difficulties. It is stable and does not burn below 700 C. At the same time, it is extremely abrasive and would probably have to be burned in an afterburner or ramjet where it would not damage turbine blades. Probably it would have to be used as a slurry in kerosene or JP-4. A slurry composed of equal volumes of boron and kerosene would have a performance index of 3.10, which is a 200% improvement over kerosene.

The chief interest in boron at this time, however, appears to be as a carrier for hydrogen in place of carbon. These carriers are the boron hydrides like diborane, (B_2H_6), pentaborane (B_5H_9), and decaborane ($B_{10}H_{14}$). On a weight basis, these fuels have a heat content up to 70% greater than kerosene. Their synthesis is not easy; for example, diborane is prepared from lithium hydride and boron trifluoride etherate. Diborane is a toxic gas which is unstable in the presence of air or moisture. Decaborane is a solid. So it can be assumed a practical boron hydride will contain about five boron atoms.

Some success is reputedly being obtained in stabilizing fuels in this range and reducing their toxicity by alkylating them. Such a fuel is HiCal, a Project Zip fuel that is to be manufactured for the Navy by Callery Chemical Co. Cost of the hydrides is high—reportedly several hundred dollars a pound for diborane and several thousand dollars for decaborane—when manufactured on a laboratory scale. Eventually it is hoped that processes will be developed that will bring the cost of boron fuels down to $1 a pound or less.

Indications that borane-type fuels are beyond the discussion stage can be found in the plans Callery Chemical Co., Olin Mathieson, and others have for building plants for their manufacture. According to reports in the press, the Air Force has authorized Boeing and North American to go ahead with the design of a bomber, the WS-110, that will use boron derivatives as fuel. This aircraft is understood to be under consideration as the successor to the B-52 long-range bomber that is now going into service with the Strategic Air Command.

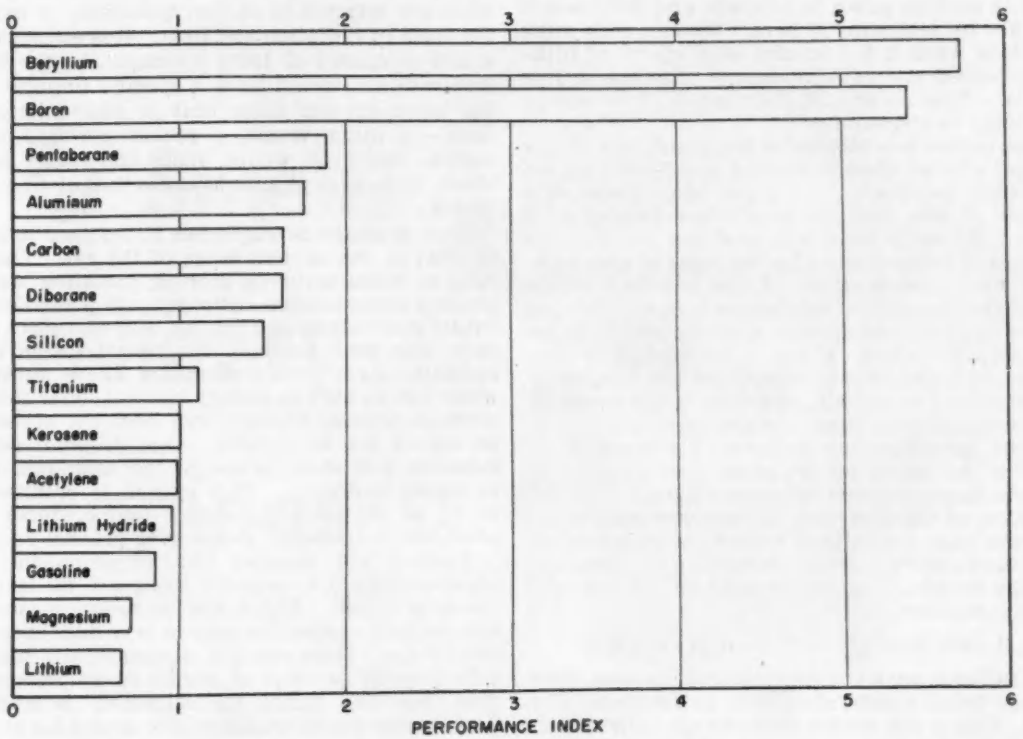
The fuels discussed so far have been thought of as being consumed in air-breathing engines. In the

Table 1—Heat Content of Fuels on Weight Basis

Fuel	Btu per lb
Aluminum	13,300
Beryllium	29,140
Boron	25,000
Carbon	14,500
Diborane	31,370
Gasoline	18,800
Hydrogen	51,570
Kerosene	18,490
Lithium	18,460
Magnesium	10,640
Pentaborane	29,127
Silicon	13,170
Titanium	8,190

Table 2—Theoretical Specific Impulse Values at 300 PSIA

Oxidizer	Fuel	Specific Impulse, sec
Nitric Acid	Aniline	221
Nitric Acid	Ammonia	225
Hydrogen Peroxide	JP-4	233
Oxygen	Ethyl Alcohol	242
Oxygen	JP-4	248
Fluorine	JP-4	265
Ozone	JP-4	266
Fluorine	Ammonia	288
Fluorine	Diborane	291
Fluorine	Methyl Alcohol	296
Fluorine	Hydrogen	352
Ozone	Hydrogen	369



RATINGS of various possible fuels in terms of a performance index which is the product of the fuel's available energy per pound and the available energy per gallon divided by that product for kerosene.

rocket field, air is no longer used as the oxidizer, and this fact opens up a whole new era for exploration. Nitric acid, hydrogen peroxide and ozone are favorite substitutes for oxygen, and there is at least one high-performance aircraft flying today that uses nitric acid and kerosene as the fuel combination.

Fuels, or propellants, as they are called for rockets—that is, fuel-oxidizer combinations—are usually rated in terms of specific impulse—I_{sp}—which equals the pounds of thrust available per pound of propellant consumed per second. Significance of the specific impulse in rocketry is apparent from the range formula

$$R \propto {I_{sp}}^2 \log^2 \frac{W_F}{W_E}$$

Where W_F = gross weight of the rocket
W_E = empty weight of the rocket

High-energy fuels on this scale are usually considered as those having a specific impulse greater than 250 sec. Table 2 gives the I_{sp} of various combinations. Here it is apparent that fluorine is superior to oxygen as an oxidizer; in fact, it is one of the most powerful oxidizing agents available. For example, JP-4 and oxygen have a theoretical I_{sp} of 248 sec, while JP-4 and fluorine give 265 sec. An even better combination is diborane and fluorine with an I_{sp} of 291 sec. Fluorine is, of course, toxic and expensive, as well as being very corrosive. Because it is a gas, it has to be stored under pressure, but mobile equipment made from nickel alloy has been developed to handle it. Cost is about $5 per lb though it could probably be brought down to about $1 per lb if the demand were high enough.

An even more powerful oxidizer is ozone which, with hydrogen, gives a theoretical I_{sp} of 369 sec. The chief drawback here is that 100% ozone tends to decompose with explosive violence. Work at Temple Research Institute seems to indicate, however, that methods can be developed for making and handling the pure product in a stable form.

While the chemists and fuel technologists are wrestling with the problems of handling and burning these high-energy fuels and propellants, we can afford to look even further ahead to see what possibilities exist for harnessing even greater energies of nature which, at the moment, are perhaps known to us, as William Paley, the eighteenth century theologian, has said, only by their effects. Atomic energy is one of these "energies of nature," and the possibilities it offers are virtually limitless. Recently the atomic submarine "Nautilus" made a 60,000-mile voyage and used only 8.3 lb of uranium. If fuel oil had been the source of energy, the 8.3 lb

would have been 17,000,000 lb or 57,140 bbl. But much has been written on the subject of the application of nuclear power to aircraft, and little would be gained by reviewing it here. We can with more profit look, even if but briefly, at a source of hitherto untapped energy—the energy inherent in *free* radicals. The results of harnessing this energy could truly be spectacular.

A free radical is a molecular fragment, free of any electrical charge, that is formed usually during an exothermic reaction. The upper atmosphere is a reservoir of free radicals which are formed as a result of the sun's radiation, and free radicals are suspected of being responsible for some of the radiation in the aurora borealis. A less remote breeding place of these chemical substances is in the exhaust gases of internal combustion engines, and they are also present in flames. It will be inferred from what has been said that these substances are formed by the absorption of energy, and this is the property which makes them especially attractive as energy reservoirs for propulsion systems. For example, as shown in the following equation, one molecule of hydrogen forms two free hydrogen radicals upon the absorption of 400 Btu, and the re-combination releases this same quantity of energy. This is equivalent to 92,910 Btu per lb, or 1.79 times the energy obtained by burning a pound of hydrogen in the conventional manner.

$$H{:}H + 400\ \text{Btu} \rightarrow H^{\cdot} + H^{\cdot} \rightarrow H{:}H + 400\ \text{Btu}$$

Free radicals are a transient state of matter, their existence being measured usually in fractions of a second. This is the reason they are not fully understood, and it is a reason that would exclude them from consideration as fuels. Recently, however, techniques have been developed for stopping free radicals in their tracks and isolating them for further investigation. Credit for this remarkable contribution to physicochemistry goes to F. O. Rice and his co-workers at the Catholic University of America, though it must be acknowledged they were continuing studies initiated by Moses Gomberg at the University of Michigan and L. Vegard, a Norwegian physicist. The Bureau of Standards is actively continuing this work under contracts with the armed services and has been successful in isolating the free radicals of nitrogen, oxygen, hydrogen, water vapor, and ammonia gas. These radicals are collected as solids at temperatures of about 4 K. When heated to 20 to 30 K they combine, releasing what are referred to as vast quantities of energy in the form of radiation and heat. It is estimated that a fuel composed of 100% hydrogen, in the form of free radicals, would have a specific impulse five to six times greater than that of conventional-type fuels—in other words, a rocket powered by free radical hydrogen would, from the range formula above, have a range 25 to 36 times that of an ordinary rocket.

This, as might be suspected, is too good to be true, at least at the present stage of the art. The problems of manufacturing, storing, handling, and controlling disassociated hydrogen are a challenge for future generations of chemists and engineers. However, this does not rule out consideration of free radicals. Less active forms of these substances, while not so high in energy content, offer more immediate promise though even here the problems to be solved are formidable. One proposal calls for isolation and stabilization of the ammonia radical in liquid hydrogen. This system is credited with an I_{sp} of 600 sec at moderate temperatures and a nine-fold increase in range over present rockets.

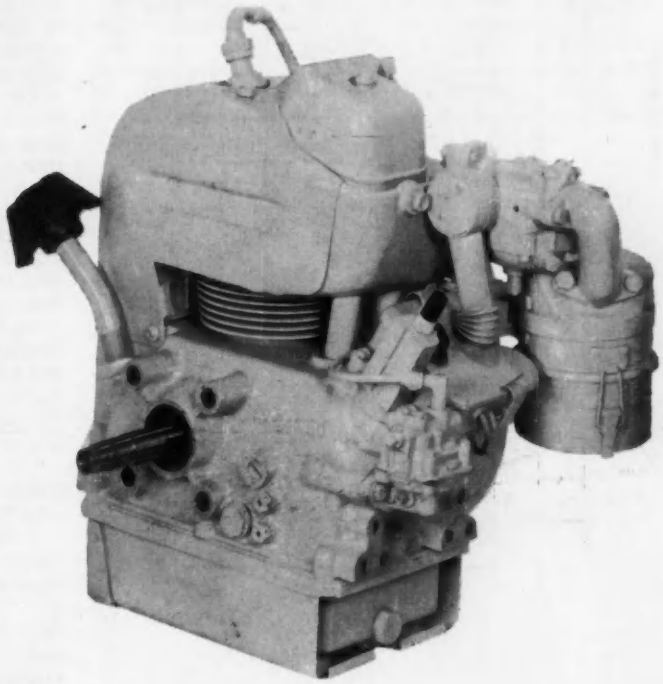
There is still another form of propulsion under consideration for vehicles designed for exploring the solar system. This is the ion rocket, a propulsion system that accelerates ions to very high speeds, say 660,000 fps. Here one has phenomenally high specific impulse or ratio of thrust to propellant mass flow, but the thrust unfortunately is negligible. Such a mechanism would only be useful for guidance of a vehicle in outer space where the gravity forces are also negligible. The ion rocket would have to be launched by a chemical rocket similar to the rocket designed for the earth satellite project. Once established in an orbit, the ion rocket could take off under its own power.

Such a vehicle is Project SNOOPER proposed by the Rocketyne Division of North American Aviation. It would employ a light-weight nuclear powerplant to generate the potential necessary to accelerate the ions. Source of ions would be cesium which would be ionized by impinging on incandescent tungsten surfaces. A d-c potential of 27,500 v would accelerate these ions to a velocity of 657,000 fps.

Advances in hydrocarbon fuels and the machines that convert their energy to work have been spectacular. But these very advances push us to explore new possibilities. Among them are fuels in which hydrocarbon molecules are replaced by substances with higher energy release per unit weight . . . fuel-oxidizer combinations for use in vehicles operating beyond the atmosphere . . . and the application of energy from free radicals or ions.

800 parts replace 23,000 in . . .

6 Small Military Engines



Based on paper by **L. D. Bakke,** Continental Motors Corp.
and
R. F. Dennis, U. S. Army Engineer Research and Development Laboratories

SIX new 4-stroke gasoline engines will supply the power for military industrial applications. The family sired by Continental Motors (½, 1½, 3, 6, 10, and 20 hp) replaces the 78 makes and models used in World War II. The first two are single-cylinder, the 3- and 10-hp engines are 2-cyl, and the others are 4-cyl engines.

800 parts will support this entire family of engines. Actually, 28 subassemblies or repair kits will cover the first three sizes. During World War II, 23,000 parts were needed for the same horsepower range of engines. In addition, 80–90% of the parts are interchangeable between the 1½- and 3-hp engines. Other horsepower engines, with the exception of ½ hp, are also highly interchangeable.

Aluminum die castings, overhead valve design, and high performance materials give engines with 1500 hr between overhauls, light weight, and enable maintenance with a few common tools. Power and weight data appear in Table 1.

Since the 1½-hp engine (see above) is representative of the design features of the family, it is used as an example. (See Fig. 1 for performance data.)

Designing the 1½-Hp Engine

A smooth-operating, light-weight 2-stroke design was dropped in favor of the easy-starting, low-maintenance, quieter, 4-stroke engine. Reason: No satisfactory combustion-chamber deposit control could be found when military fuels and lubricants were used, therefore, spark plugs didn't last long enough.

Hemispherical combustion chambers used in the final design produce high turbulence and minimum deposits even with highly leaded fuels.

A 6/1 compression ratio allows a fixed spark setting. Fuels of 72 octane burn without detonation . . . and various grades of JP-4 fuel will start and operate the engine in ambients of 0–125 F.

A die-cast aluminum cylinder head is used for the first time in an overhead valve design. Intake and exhaust valves and the spark-plug insert are cast in the cylinder head. Cooling is accomplished by a cast passageway between the valve guides and fins on the exhaust port and combustion areas.

A rectangular connection between the carburetor and intake valve evaporates fuel that could condense and puddle in a tube. It also gives the maximum port size in the space available.

A single die casting produces the crankcase and the single cylinder, complete with a steel liner (Fig. 2). The cylinder barrel and cooling fins are concentric to give uniform thermal expansion. Steel, self-tapping inserts are driven in die cast holes for extra strength at equipment- and engine-mounting locations. A 35–45 microin. surface finish is held on the cylinder bore. Chrome plating of the bore was not

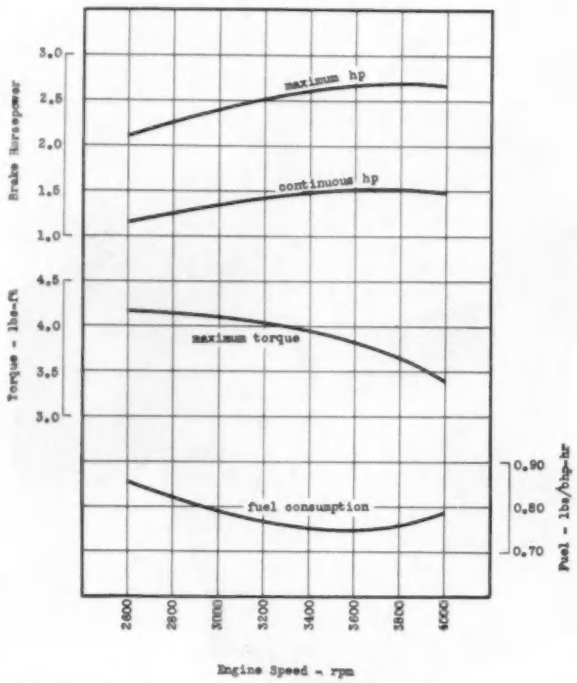


Fig. 1—Performance characteristics of model 1A08 military engine.

Table 1—Extensive Use of Aluminum Die Casting in 1½-Hp Engine Keeps Price and Weight Down

	Weight (Less Inserts), lb
Elbow—Air Cleaner	0.09
Rod—Oil Gage	0.11
Yoke—Spring and Cable	0.04
Housing—Throttle Control	0.06
Manifold—Intake	0.18
Cover—Rocker Box	0.24
Flyweight (2 per Engine)	0.52 (2 pieces)
Cylinder Head	1.72
Cap—Accessory Housing	0.63
Crankcase	4.60
Oil Pan	1.12
Bearing Cap	1.62
Flywheel	2.45

used, since tests did not show improved performance.

Using tin-plated 24C aluminum (Alcoa XC-165) eliminates special bearing materials on both ends of the forged-crankshaft. Clearances are set for minimum operating temperatures to prevent the aluminum rod from locking up on the crankpin.

Two tapered roller bearings support the radial and thrust loads of the crankshaft. An integral timing gear also supplies power for the camshaft and connects with the starter. Two types of power take-off are machined on the end of the crankshaft. The first is a keyway cut in a cylinder and the other, a tapered end with tapped hole. The first is for belt sheaves, chain sprockets, and clutches and the second for generator quills, pump impellers, and heater fans.

Push-rods are made of aluminum to match the thermal expansion of the cylinder. The valve closing rate has been increased to prevent torching and to crush combustion-chamber deposits that might be lodged on the valve insert seat. Positive rotators are located at the valve stem extremity.

Valve overlap must be minimized in a general-purpose engine to insure good starting and idling, as otherwise the carburetor "senses" the overlap pulse.

A splash-vapor oil system accommodates a wide range of lubricants. Oil splash starts in the crankcase and is controlled by a metering hole. (See Fig. 3.) Vapors are forced up the push-rod cover and directed principally to the exhaust valve. Vapors are then piped to the air cleaner and taken into the combustion chamber, eliminating vapor emissions from the engine. A safety valve in the rocker box guarantees lubrication if the pipe to the air cleaner is blocked.

A centrifugal fan, integral with the die cast aluminum flywheel, supplies cooling air for operation from – 65 to 125 F. Air is passed over the cylinder head and top portion of the barrel to an exhaust heat exchanger, then to a chamber around the oil pan. No levers, thermostats, or dampers are used.

Carburetor icing is forestalled by high heat conduction to an aluminum die cast carburetor. However, fuel boiling has not occurred in ambients of 125 F.

Provision for rope, rewind, or electric starter is supplied. An overrunning clutch and throw-out design with quality materials insures foolproof operation. This is necessary since the mechanism is inside the crankcase to afford protection and lubrication.

Table 2—Power and Weight of Six New Standard Military Engines

Model	Continuous Rating, hp	Rated Speed, rpm	Operating Speed Range, rpm	Displacement, cu in.	No. of Cylinders	Bore, in.	Stroke, in.	Life between Overhauls, hr	Approximate Weight, lb	Size Generator for which Suitable, kw
1A03	½	3600	2600–4000	3.00	1	1¾	1¼	1500	15	0.15
1A08	1½	3600	2600–4000	7.95	1	2¼	2	1500	25	0.50
2A016	3	3600	2600–4000	15.90	2	2¼	2	1500	40	1.5
4A032	6	3600	2000–4000	31.80	4	2¼	2	1500	70	3
2A042	10	3600	2000–4000	42.40	2	3	3	1500	90	5
4A084	20	3600	2000–4000	84.80	4	3	3	1500	175	10

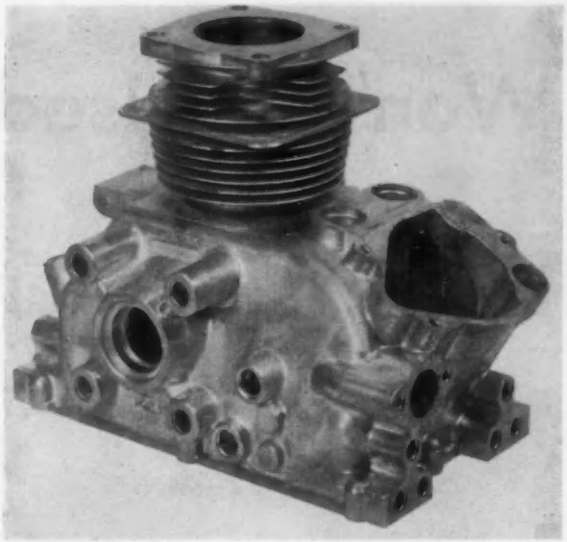


Fig. 2—Single die casting of crankcase and cylinder for 1½-hp engine. Steel liner is cast in cylinder. Inserts are driven into mounting and attachment holes.

Speed is controlled by a flyweight governor capable of fixed or manual speed control.

An 18-mm spark plug is fired by a magneto ignition system. High current drain for radio suppression prompted the use of a large alnico magnet rotor for the magneto.

Maintaining the Engines

Accessories are on one side of the engine for easy servicing. Covers and caps can be removed with gloved hands, without tools. No special equipment is needed for arctic or tropic operation.

Oil capacity of one pint runs the 1½-hp engine for 24 hr, though 8-hr intervals are recommended. Design oil consumption is reached in an average of 50 hr.

Extensive use of die castings has kept the engines light and easy to handle. See Table 2 for die cast parts.

Costs

Estimates place the price of the engine 10% above militarized commercial counterparts. This increase is offset by the 500–1000 hr of extended life between overhauls and the reduction of parts to be stocked. Several thousand dollars are needed to catalog, store, and issue each line item in the military supply system.

(Paper, "New Small Military Standard Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y . Price: 35¢ to members; 60¢ to nonmembers.)

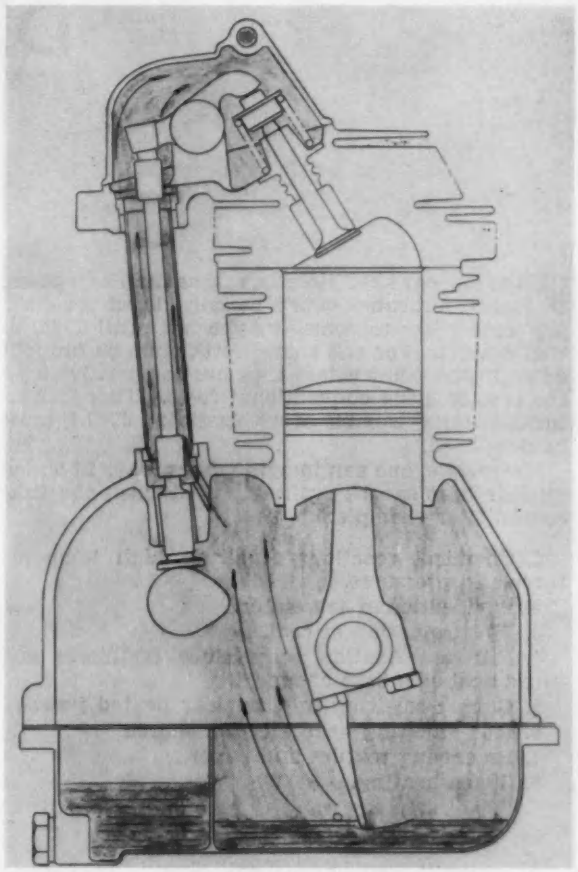


Fig. 3—Oil vapor is sucked through push-rod tube, over rocker and valves, to the air cleaner. Noncondensed vapor is taken into the combustion chamber and burned in the engine.

New Road Program Sees Greater Equipment, Material, and Labor Requirements

■ *It is estimated that there are 300,000 pieces of construction equipment in use today. Our new road program will require 57,000 additional units a year for every billion dollars worth of work over 1956 requirements.*

22% more steel will be needed in 1957, 33% in 1958, and the peak years 1960–1967 will see 42% more steel per year than in 1956. 28% more cement will be needed in 1957, 39% in 1958, and the peak years will find a 54% increase per year. Highway materials, such as bituminous materials, petroleum products, lumber, timber piling, explosives, clay pipe and tile will accelerate in about the same proportion as steel, 22% next year, 33% in 1958, and 42% during the peak years.

It is expected that the 220,000 men used on highway construction will rise to 350,000 men by 1958 and 500,000 men by 1961. This increased labor force, however, will not be much more than enough to operate the additional equipment.

—I. T. White

Nuclear Heat Won't Be Used DIRECTLY in Near

USE of nuclear heat *directly*, rather than as a power source, probably won't be considered seriously for some years to come—maybe not until 1975, or thereabouts. For one thing, costs must be brought down to the point where they are competitive with the cost of using conventional fuels. Then, structural material capable of withstanding 3000 F must be developed.

Meanwhile, one can imagine many ways in which nuclear heat can be profitably used when the time comes. For example:

1. Chemical reactions requiring high temperatures and pressures.
2. Purification of salt water.
3. Hydrogenation of coal.
4. Nitrogen fixation to produce fertilizers and nitric acid as a base chemical.
5. Copper smelting in a nuclear heated furnace.
6. Iron smelting near the iron source.
7. Processing textiles and paper.
8. Space heating.

Costs

Although it seems pretty well agreed that nuclear energy for process heat is not yet competitive with commercial fuels, there is actually no agreement on what the cost of such heat would be today. Estimates range from a truly optimistic 10¢ per million Btu to perhaps a more conservative and realistic $1 per million Btu of process steam. This value is to be contrasted with process steam costs delivered in an oil refinery today of about 50¢ per million Btu. Because of the availability of combustible byproducts, this figure is much lower in some industries.

Organic fuel costs are bound to go *up* just due to scarcity alone. But there is real promise that energy costs of nuclear fuels will go *down* because of improved technology and experience. It would appear, therefore, that for the long-range future we should not discount nuclear sources for process heat.

This is especially true for industries in countries where fuel costs are already high and sources somewhat uncertain. Also, for industries like paper pulp whose bulky raw materials are far from the processing plant, process steam from nuclear reactors might conceivably be competitive with conventional fuels.

On this point the McKinney Report on the Peaceful Uses of Atomic Energy notes that in the period 1975–1980 as much as 44% of the newly installed process heat producing facilities may depend on nuclear energy.

High-Temperature Material Needed

Oxide-type nuclear fuels capable of operating at 3000 F are coming increasingly into favor. So far, however, structural materials capable of withstanding this temperature have not yet been developed. But promising research is being performed on ceramic coatings and on cladding metals of high melting point and good nuclear characteristics, such as columbium.

High-Temperature Chemical Applications

Of the total energy consumed in the United States about 10% is used as process heat in production of metals, chemicals, glass, cement, paper, petroleum, and rubber products. By 1980 it is forecast that the requirement for process heat will be three times what it is today.

Thus, one can easily visualize the chemical plant of the future as a completely integrated and complex unit. It may rival, in the words of the McKinney report, "the legendary meat packing plant that uses all the pig except the squeal." Heat will be used for processing, driving chemical reactions to completion. Other, more subtle reactions may require the radiation from the reactor to drive low-temperature reactions to completion. Fission byproducts will be sold for tracer work.

This example points up some of the unique advantages of nuclear heat :

1. Lack of combustion products.
2. No need for oxygen to sustain combustion.
3. An inherent possibility of attaining far greater temperatures than are feasible or can be obtained economically with other fuels.

Future

Based on talks by

A. A. Kucher, Ford Motor Co.
T. F. Nagey, Martin Co.
H. J. Ogorzaly, Esso Research & Engineering Co.

Talks given before a meeting of the SAE Nuclear Energy Advisory Committee.

In some high-pressure and high-temperature chemical reactions, process heat is now generated internally by expensive methods, such as combustion with oxygen, in order to:

- Increase the attainable temperature.
- Reduce losses in the product collection system.
- Avoid the necessity of transferring high-level heat across pressure-retaining walls.

For such operations nuclear heating may be a possibility. It would have the advantage, too, of providing greater flexibility in the composition of the reactant gases.

Purification of Salt Water

Conversion of salt water into a form suitable for industrial, agricultural, and human consumption has received wide attention. One high government official recently forecast the existence of pipelines transporting purified seawater hundreds of miles inland for these purposes. While installations of this sort probably will not materialize within the near future, the chronic water shortages of such coastal cities as Los Angeles could be alleviated by relatively simple systems. Thus, it is interesting to speculate on the economic and technical feasibility of using combination power generation and water purification units to meet the growing needs of our cities.

Conservative analysis indicates that a combination power generating and water purification plant using a heavy water (D_2O, deuterium oxide), moderated reactor fueled with natural uranium oxide (UO_2) and having a power output of 50,000 kw could produce 6,000,000 gal of water daily for 58½¢ per 1000 gal. This water cost compares favorably with the $1.50 per 1000 gal figure the government has indicated to be the maximum meriting the interest of the Department of Interior. For estimating purposes, capital investment was assumed amortized over a 20-year period. The corresponding power cost was found to be about 11 mills per kw-hr. These figures indicate that combination power generating and water purification units using nuclear fuel may become economically feasible within the next few years.

Because energy must be made available for water purification purposes, condenser pressure in this combination unit cannot be as low as that in a conventional power generating unit. Condenser pressure is taken at about 20 psia. Assuming inlet conditions of 1000 F and 515 psia, energy used for power generation is about 345 Btu per lb, while energy used for water purification is about 977 Btu per lb, for a total energy utilization of 1322 Btu per lb. A conventional turbine cycle using identical inlet conditions and condensing to 2½ in. of mercury pressure could utilize no more than 539 Btu per lb.

Hydrogenation of Coal

It was reported that a Koppers Co. study showed nuclear heat could be applied to coal to produce synthetic gasoline for 6¢ per gal.

Use of Low-Quality Steam

The following uses of steam at relatively low temperatures and pressures suggest themselves:

1. Processing textiles, paper, and other products.
2. Heating factory and office space.
3. Heating military installations in the Arctic and other remote areas.

The first two applications obviously need not involve the use of steam produced by nuclear plants. They are presented only as offering possible outlets for low-pressure steam made available as conventional fossil-fueled powerplants are replaced by nuclear power reactors.

It might also be pointed out that, unless a population density of the order of 10,000 per square mile were to be serviced, and for a long season, the cost of the distribution system alone would be more than the cost of coal for residential heating. One area that might prove attractive is New York City.

Use of nuclear generated low-quality steam for heating military installations in remote areas is a logical extension of the possible use of nuclear power reactors for power generation and/or water purification in such areas.

Why the Free-Piston May Invade

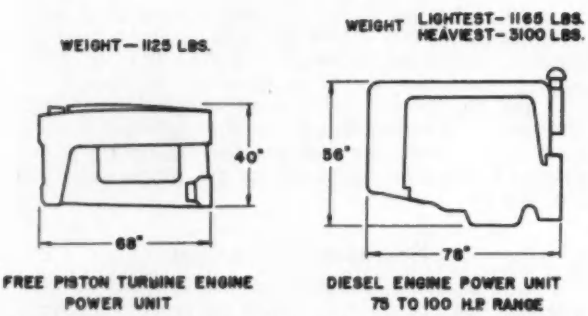


Fig. 1—Size and weight comparison of free-piston engine and diesel engine show free-piston engine to have the advantage in both respects.

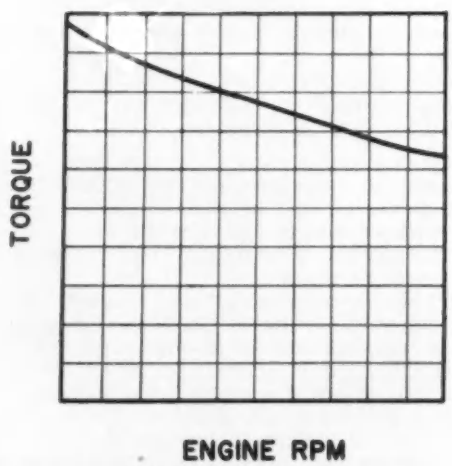


Fig. 2—Turbine engine has unusually flat torque curve.

THE free-piston turbine engine appears to be an ideal powerplant for the farm tractor. It has the economy equivalent to, or better than, that of a diesel piston engine. It has the response and flexibility of a gasoline engine. An auxiliary starting engine is not required, such as those necessary with most diesels of equivalent size in mobile use. A wide range of engine sizes can be economically produced from the same manufactured parts. It is adaptable to a wide range of fuels. And last, but most important, the torque characteristics are ideal.

The physical size and weight to horsepower ratio of the free-piston engine is favorable for farm tractors or industrial power. The size and weight of the power package used in the Typhoon tractor is compared with a typical diesel power unit of equivalent power rating in Fig. 1. The outlines shown and weights quoted are for an industrial power package with all accessories, less skids.

The free-piston turbine engine fits well into a tractor, where a long, low silhouette is desirable. More freedom for configuration and mounting is allowed with the free-piston powerplant. The gasifier is approximately 37 in. long and 16 in. in diameter, and is the major determining factor in the size of the power package.

The free-piston power unit with all accessories and auxiliary gear box is 40 lb lighter than the smallest equivalent tractor diesel power unit, and 1975 lb lighter than the heaviest—a 100-hp engine.

There is a growing trend toward the diesel engine for farm tractor powerplants, particularly in the larger sizes. Industrial users have been taking advantage of the diesel engine, with its good economy and lugging characteristics, for many applications. Preliminary tests have shown that the free-piston turbine engine may equal or surpass the diesel in economy. Also, its adaptability to a wide range of hydrocarbon fuels may be an important consideration in the future.

Flat Torque Curve

Much design time and engine development work is done on reciprocating engines to get a flat torque

Engine the Farm

HERE IS PART II of the Ford free-piston-engine farm tractor story.

Last month Oscar B. Noren described the engine and some of the difficulties encountered in its development.

In the present article, Robert L. Erwin tells why this engine was installed in a farm tractor, and some of the results being obtained.

Excerpts from paper by **Robert L. Erwin,** Tractor & Implement Division, Ford Motor Co.

curve. The best of these cannot approach the torque curve of the turbine engine in its application to farm tractor work (Fig. 2). Due to the varying load encountered in field-work with the farm tractor, this is a very important characteristic and one that gives the free-piston turbine engine a big advantage over conventional farm tractor engines.

To achieve best economy with a farm tractor it must be worked near its peak drawbar pull. Only the part of the engine power reaching the implement through the drawbar is converted to useful work. The two largest losses are the rolling resistance of the tractor and the slip of the drive wheels. The rolling resistance of the tractor is practically the same, regardless of the drawbar pull. The losses due to slip can be excessive if the drawbar pull is too great. On the other hand, if the drawbar pull is too low, the loss due to rolling resistance is a large percentage of the total power output. The proper balance between the two is necessary to achieve maximum efficiency. Tests have shown that, with heavily weighted wheels, the maximum tractive efficiency is obtained when the tractor is worked at 75–80% of the maximum drawbar pull. This is shown in Fig. 3.

An 80% drawbar pull would be easily maintained if the soil and the implement loads were constant. However, this is not likely in most farming condi-

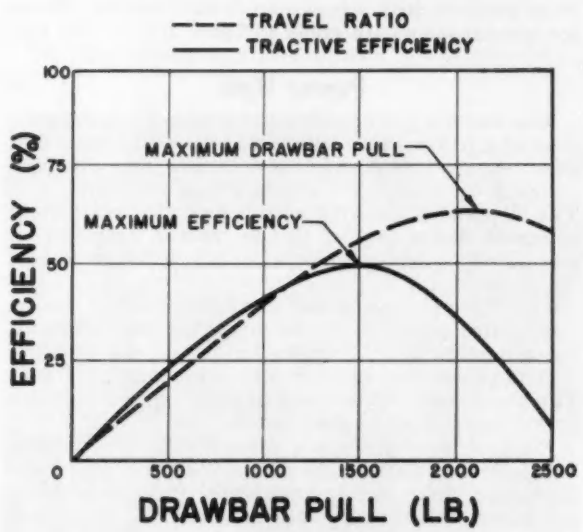


Fig. 3—Tests show that, with heavily weighted wheels, maximum tractive efficiency is obtained when tractor is worked at 75-80% of maximum drawbar pull.

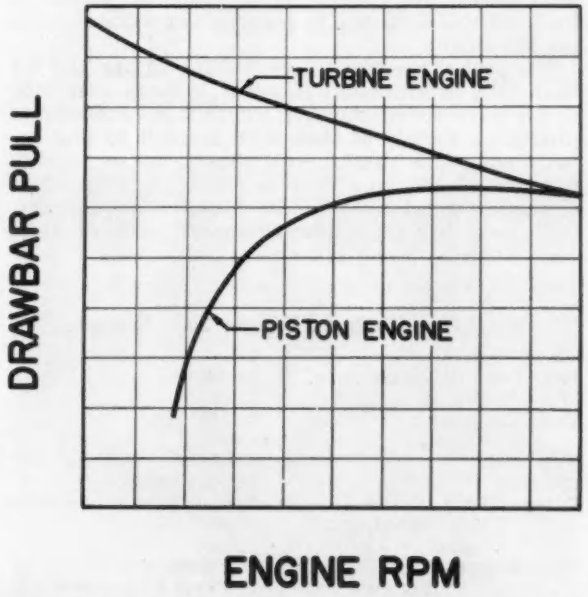


Fig. 4—Turbine engine, unlike piston engine, will deliver increasing drawbar pull down to stall speed.

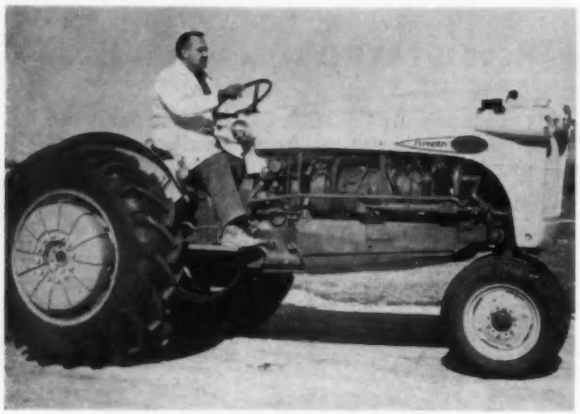


Fig. 5—Ford Typhoon tractor.

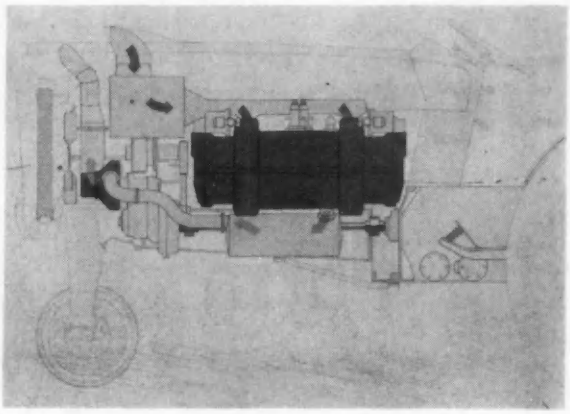


Fig. 6—Power unit installed in farm tractor.

tions. If traction conditions are good and the tractor is being worked at its most efficient loads, an increase in drawbar pull will slow down the engine. When the speed reduction is enough to pull the engine speed down on the descending part of the curve, either the engine will stall or a gear ratio change must be made. Usually, the reduction in ground travel does not reduce the load enough to compensate for the reduction in torque delivered to the rear wheels.

For purposes of comparison, engine torque has been converted to drawbar pull delivered as torque at the drive wheels for the turbine engine and a conventional tractor engine (shown in Fig. 4). Thus, it can be seen that the turbine engine will deliver increasing drawbar pull down to stall speed. However, for most practical applications the increased drawbar pull would allow the tractor to move through the field under the conditions causing the increased load, without a change in gear ratio or without stalling the engine.

The cost of the free-piston turbine engine has not been fully determined. However, it lends itself well to farm tractor production, where it is necessary to produce a variety of sizes with a small tooling investment. The gasifier unit shown can be used to produce 50–150 hp. With a minimum number of changes, several different size engines can be assembled from the same manufactured parts or from parts made on the same tooling. This would allow economical manufacture of several sizes of tractors.

Table 1— Typhoon Tractor Specifications

Wheel Base, in.	99
Rear Tread (Adjustable), in.	60–84
Weight—Dry, lb	4200
Tire Size—Rear	13×30
Front	6:00×16
Front Axle	Tricycle
Steering	Power steering
Engine—Type	Free-piston turbine engine
Rated Speed, rpm	43,000
Fuel	Diesel
Transmission—Type	Full power shift
Speeds	10 forward—2 reverse
Overall Height, in.	70
Overall Length, in.	144

Tricycle Tractor Selected

A tractor of conventional tricycle configuration (Fig. 5) was selected because it is typical and because it was easily adaptable to the free-piston engine. Also, the tricycle tractor could be used with a large variety of production farm implements. This was desirable because the engine is to be tested in as many different farm operations and under as many conditions as possible.

Many standard tractor parts were used in building the Typhoon tractor. Due to the size and horsepower potential of the engine the tractor was made larger than other Ford tractors. Larger rear tires were used. A power shift feature was provided in the transmission to keep the turbine connected to the load at all times.

Fig. 6 shows the arrangement of the gasifier, turbine, gearbox, and accessories in the tractor. Tractor specifications are given in Table 1.

Power Unit

The turbine power unit used in the Typhoon consists of a 5½-in. turbine wheel and a 7.17 reduction gear. An overspeed cutoff, a governor, and a turbine gearbox oil pump are incorporated into this unit. The oil cooler furnished with the power turbine was removed and attached to the tractor radiator. A second oil cooler is provided in the radiator to cool the gasifier oil.

Fig. 7 shows the power turbine attached to the tractor accessory drive gearbox. This gearbox has a 3/1 reduction gear, to make an overall reduction of 21.5 between the turbine and transmission input. The standard turbine speed of 43,000 rpm is reduced to 2000 rpm transmission input.

From this gearbox are also driven the gasifier scavenge and oil pressure pump, the tractor hydraulic system pump, and the generator and power steering pump (not shown in the schematic). These are gear-driven from the transmission input gear. A belt drive from the upper shaft in the accessory gearbox drives the fan, water pump, fuel pump, and tachometer. Fig. 8 shows the gearbox with the trac-

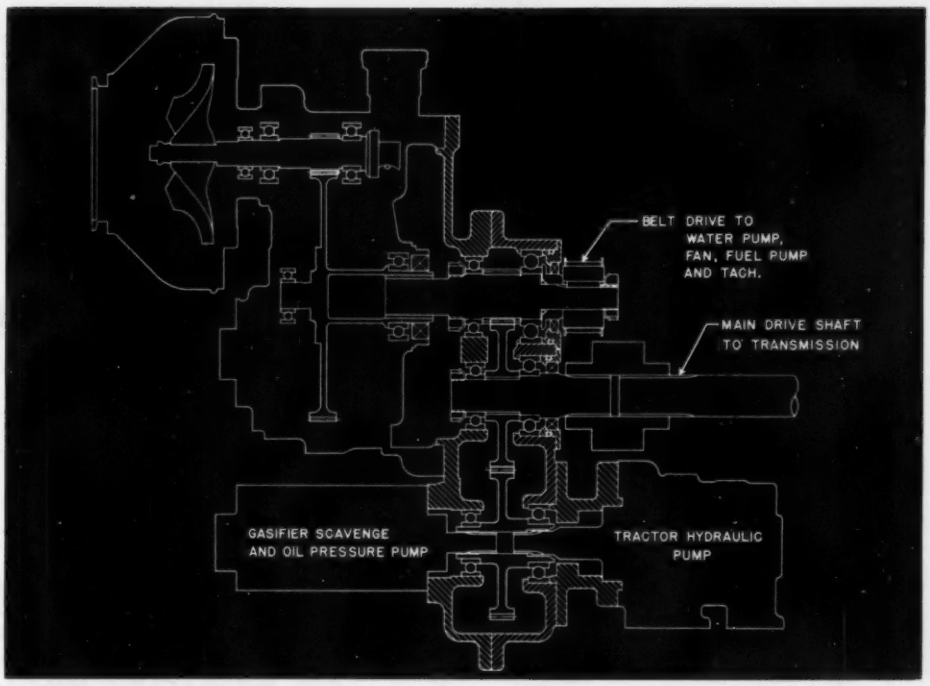


Fig. 7—Power turbine and accessory gearbox.

tor hydraulic system pump and the generator in place. Fig. 9 shows the belt-driven units mounted on top of the gearbox.

The air consumption of the free-piston turbine engine is two to three times that of an equivalent diesel. The air cleaner uses six 8-in. OD by 2-in. thick paper air filters, and air is drawn through a scoop on top of the sheet metal near the forward end of the tractor.

Another accessory unique to the free-piston engine is a high-pressure air bottle used to provide starting air for the gasifier. This was located alongside the fuel tank under the sheet metal.

The performance of the tractor power unit has been satisfactory in tests to date. The engine operates very smoothly and is practically vibration-free. Mufflers are not necessary, as the noise level is low. A turbine whine is perceptible at idle speeds but is not audible at working speeds. Many changes and improvements are constantly being made as the tests progress.

(Paper, "Free-Piston Turbine Power for Farm Use," by Robert L. Erwin, plus paper, "Free-Piston Tractor Powerplant," by Oscar B. Noren, on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

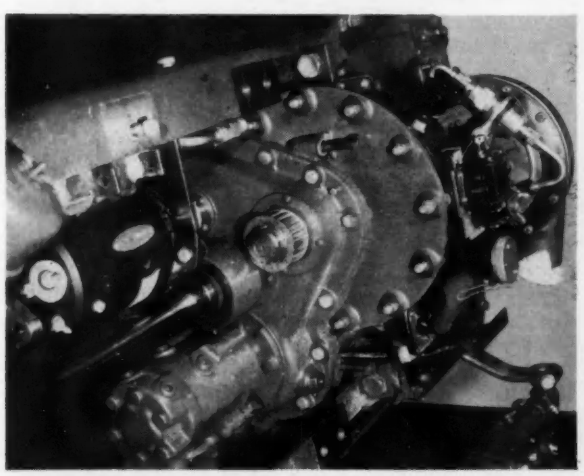


Fig. 8—Tractor accessory drive gearbox with turbine unit, generator, and tractor hydraulic system pump.

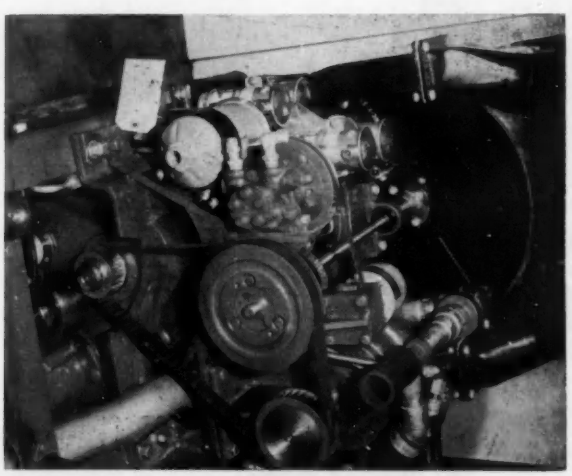


Fig. 9—Accessory gearbox with belt-driven water pump, fuel pump, and tachometer generator.

Chem-Mill Reduces Fabrication

Fig. 1—Formed rib cap extrusion with flange tapered by Chem-Mill.

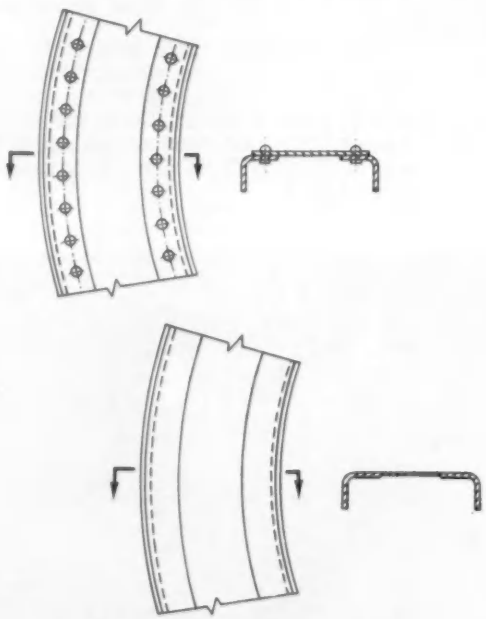


Fig. 2—Comparison of conventional frame assembly (upper) with Chem-Mill frame assembly (lower). Chem-Mill eliminates many of the fabricating operations associated with the conventional assembly.

CHEM-MILL is a chemical metal-etching process. Aluminum, titanium, magnesium, and many alloy steels may be etched without materially altering physical and mechanical properties. Thickness tolerances of the process run as low as 0.002 in. plus the actual sheet tolerance and panels may be designed with varying depths by progressively unmasking during etching.

Chem-Mill is not recommended for use on castings, and metal surface irregularities, such as dents and scratches, are amplified by the process.

This article discusses some of the important advantages of the Chem-Mill process.

BESIDES saving weight, the Chem-Mill process has a number of other advantages:

- It permits tapering of stretch formed parts.
- It simplifies application of fasteners to sandwich panels.
- It reduces welding problems.

Chem-Mill permits a reduction in cross-sectional area, and thus weight, of extrusions, forgings, and formed parts which would otherwise be heavier due to limtiations of the extruding, forging, or forming process.

Tapering skins and extrusions is a simple matter for the Chem-Mill process. For example, consider the formed rib cap extrusion shown in Fig. 1. With Chem-Mill, the extrusion is first formed as a uniform area section; then the flange is tapered by timed immersion into the etching solution. With normal machining methods, cutting this taper before forming is both costly and difficult. If the part is formed first, machining the taper is difficult and impractical.

Based on paper by **L. G. Hall,** North American Aviation, Inc.

Problems

Fig. 2 compares a conventional frame assembly with a Chem-Mill frame assembly. The conventional assembly (upper) has three routed parts, two forming operations, and a riveting operation. The Chem-Mill assembly (lower) has one routed part, which is then formed and etched. If desired, a second etch could taper the flanges, at low cost and with an appreciable saving in weight.

Chem-Mill in Sandwich Applications

Another good design application for Chem-Mill is in honeycomb sandwich construction, particularly where fasteners are used. For protruding head rivets (Fig. 3), the thicker land provides adequate bearing, and in flush riveted joints the necessity for dimpling is eliminated. Dimpling along the edge of a honeycomb panel is particularly bad because the dimpling has to be done before bonding and the riveting after bonding. The chance of the dimples matching or being free of adhesive after bonding is remote. In any case, the machined countersinks in the Chem-Mill facings would reduce assembly time.

For contoured honeycomb sandwich parts, the elimination of dimpling is even more advantageous. Since the fit between the skin and core is critical, any operation in the fabrication process which tends to alter the skin after forming is bad. Dimpling tends to stretch and oilcan the sheet. Machined countersinks in the Chem-Mill panel can be added after bonding and will eliminate these adverse conditions.

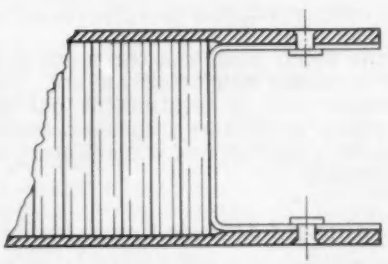


Fig. 3—In honeycomb sandwich construction, the thicker land provides adequate bearing for protruding head rivets. With flush riveted joints, Chem-Mill eliminates the need for dimpling.

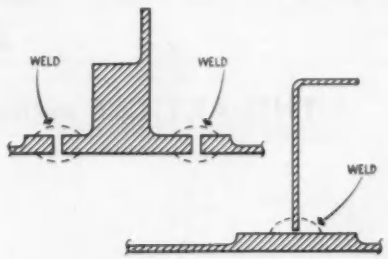


Fig. 4—Raised lands, provided by Chem-Mill, reduce welding problems.

Reduced Welding Problems

Aircraft with welded skins are now being produced to a limited extent, but currently are being designed extensively. Here the designer will find Chem-Mill the answer to a number of problems. At welded butt joints, a raised land may be used to compensate for the reduction in allowables at the weld. At a welded joint between comparatively heavy structure such as frames or longerons, and a thin skin, a raised land on the skin of comparable thickness is required to obtain a good weld joint. Fig. 4 gives an example of each of these applications.

(Paper, "Application of Chemical Milling to Airframe Structures" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Airspeed-Altitude Now Aerial

AIRSPEED-ALTITUDE compatibility and turbulence behind and below the tanker aircraft are the most serious problems facing aerial refueling designers.

Both the flying boom and the probe-drogue systems are operating satisfactorily in use. They are in an equivalent state of development, but the probe-drogue system needs more adequate pressure control to the receiver aircraft and surge protection for the tanker aircraft.

Airspeed-Altitude Compatibility

Faster development of receiver aircraft than of tanker aircraft has made airspeed-altitude compatibility between the two a serious problem of aerial refueling. Tanker aircraft have been predominantly of lower performance, thus making it necessary to refuel at lower-than-desirable air speeds and altitudes.

In refueling B-47's from the KC-97 tanker, for example, it is sometimes necessary for both tanker and receiver to go into a descent to pick up air speed in order to maintain contact.

Consequently, the KB-50 aircraft, modified to a probe-drogue tanker configuration, is being given serious consideration for an additional modification to install jet engines on wing pods. If accomplished, this modification will significantly improve the compatibility between the KB-50 and fast, tactical receiver aircraft.

In another case, a B-47 is to be prototyped to a probe-drogue tanker configuration.

The "buddy package" refueling concept is also being developed to help minimize the airspeed-altitude compatibility problem. This concept involves converting a combat-type airplane to a tanker configuration—and using probe-drogue refueling.

The conversion consists of mounting the refueling gear in an external removable pod, which can be mounted on a wing pod or centerline store position. This pod would be capable of quick installation and

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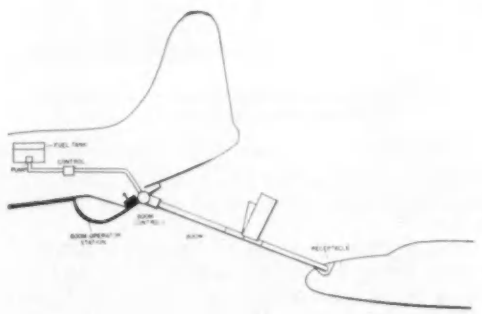
THIS ARTICLE outlines improvements underway in the two types of



FLYING BOOM SYSTEM has a semi-rigid telescoping member capable of swiveling throughout a "contact envelope". This boom is equipped with control surfaces called rudder-vators, which the boom operator controls.

To refuel, the receiver aircraft flies into position behind the tanker. Then the boom operator "talks" or signals the receiver into position. In position, the boom operator makes the contact by telescoping the boom. . . . The boom nozzle is locked in position by toggles in the receptacle in the receiver. After the fuel transfer, disconnect may be initiated either by the boom operator, the receiver pilot, or automatically by a high-fuel-pressure disconnect-switch.

Compatibility Refueling Problem

Based on paper by **Paul G. Schloemer,** Fuel and Oil System Section, Wright Air Development Center

removal. Thus, a particular aircraft would have the flexibility to serve double duty as a tanker or combat aircraft.

Should range become necessary to hit outlying targets, one of a pair of combat aircraft could be converted to a tanker. These aircraft would then take off and fly together to a refueling point, where fuel would be transferred. The tanker would then return home—and the receiver would continue to the target. A picture of such a system under development is shown at the top of page 34.

Improving Fuel Pressure Control

In general, refueling system pressure controls and control methods are satisfactory. But improvements to optimize control systems are still to be made.

In the KC-57 aircraft, inlet pressure to the receiver aircraft was monitored by a manual control provided at the flight engineer's station. Disadvantage was that it gave additional duty to an already-busy flight engineer. Result: Fueling was often accomplished at less than rated pressure . . . and high-pressure disconnects sometimes resulted because the flight engineer couldn't reschedule the system promptly as tanks shut off in the receiver aircraft.

So, Wright Air Development Center engineers encouraged development of automatic controls to continuously monitor and maintain the standard 50 ± 5 psig at the inlet to the receiver. This worked out satisfactorily. Consequently, the Air Force now requires automatic pressure control on all new tanker aircraft.

The throttling-type control (which compensates for changes in hose pressure drop with flow) now used on multi-point probe-drogue tankers does not compensate for pressure variations due to the position of the receiver in the contact envelope. So, a throttling-type control is being evaluated which

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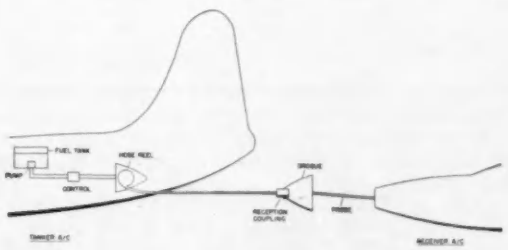
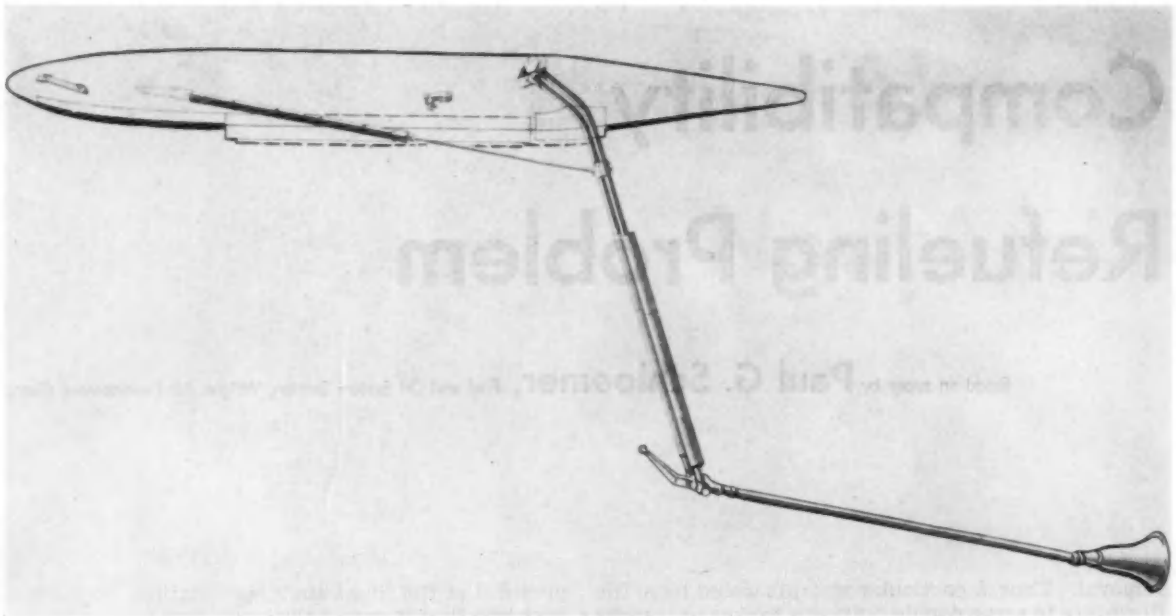
operational aerial refueling systems which the Air Force currently uses.

PROBE-DROGUE SYSTEM has a hose or folding-pipe mechanism trailed from the tanker and stabilized by a conical-shaped drogue. Inside the drogue is the reception coupling. A probe nozzle engages the reception coupling.

To refuel, the receiver pilot flies the probe into the drogue. Automatic coupling occurs, and fuel transfer takes place.

To initiate disconnect, the receiver pilot eases back on the throttles and reduces speed. The hose pays out and the receiver drops back until the hose reaches full trail. There, the breakaway load imposed by the receiver causes a disconnect.





UNDER DEVELOPMENT is the above system of refueling which is aimed to minimize airspeed-altitude compatibility problems. It utilizes the "buddy package" concept—which consists of converting a combat-type aircraft to a tanker configuration to permit double-duty as the situation may require. The refueling gear would be mounted in an external removable pod—which could be mounted on a wing pod or centerline store position. The concept utilizes probe-drogue refueling and folding pipes in place of a hose reel.

can be installed at the end of the hose, just upstream of the reception coupling.

Surge Control Problems

Serious thought is being given to requiring surge tests on combined tanker-receiver refueling systems before flight tests. Recent unfortunate incidents indicate the desirability of such tests to insure that the combination is safe.

Surge protection for probe-drogue tankers has not been entirely satisfactory. During tests on a simulated KB-50 fuel transfer system, for example, disconnects at a flow rate of 300 gpm produced surge pressures at the drogue of approximately 600 psi.

The surge dampening characteristics of the hose reduced the 600 psi by 25 to 30%. So, the tanker system was subjected to pressures of approximately 420 psi.

Tests made with a surge arrester installed just upstream of the hose reel were then made under the same flow conditions. Surge pressure at the drogue stayed about the same. But the reel outlet pressure was reduced to about 240 psi.

To permit higher-rate refueling from the KB-50, it was necessary to strengthen the hose reels to withstand surge pressures of 325 psi, which were experienced during disconnect at a flow rate of 425 gpm.

A WADC design study has indicated the feasibility of providing surge protection at the reception coupling.

(Paper, "Progress in Aerial Refueling," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

Don't Overload Automatic

■ *You cannot overload an automatic transmission-equipped vehicle and get away with it. The whole power train is engineered for a certain job and does it well. But it will not stand overwork.*

—G. H. Maxwell, Hertz Corp.

New Chrysler Suspension System Features 9 Design Changes

Based on paper by **O. D. Dillman and R. R. Love,** Chrysler Corp.

HOW near Chrysler has come to reaching its nine goals in improved automobile ride is a story of engineering development which started more than 10 years ago. The first designs aimed toward the nine goals were quite different than the production design which ended up on the 1957 models (Fig. 1) . . . but each of the experimental designs made a contribution.

The list of goals to start with looked like this:

1. Reduce high-speed float.
2. Minimize harshness during boulevard ride.
3. Cut down steering effort.
4. Lessen road noise.
5. Increase high-speed directional stability.
6. Stop the front end from doing a nose-dive on braking.
7. Help production to maintain car heights on the line.
8. Eliminate chassis lubrication.
9. Give better balanced ride.

1. High-Speed Float

High-speed float—which is a bobbing motion of the front end of the car when it is driven over an undulating road—is considerably helped by the use of a new shock absorber on the front suspension. Its additional set of valve discs and orifices provide greater shock absorber resistance at low piston velocities while still avoiding the harshness of a stiff-legged ride.

2. Boulevard Ride Harshness

Lower-pressure, greater-cross-sectional-area tires lower spring rate of tires and improve boulevard ride harshness. The 14-in. diameter, 22-psi tires have a considerably greater bump-absorbing power and 10% less harshness than the 15-in. diameter tires.

Suspensions with lower friction will deflect under small road surface irregularities and allow the car to ride on the suspension springs. This reduced static friction becomes possible by eliminating sliding friction of the pivot points and replacing it with rubber deflection. The fore-and-aft movement of the front suspension helps reduce single-bump impact harshness by about 20%. Fig. 2 shows the lower control arm and front strut mounting assembly.

3. Steering Effort

Reduced friction of the ball joints and steering linkage counteracts possible increased steering effort. This is accomplished by changes in design (Fig. 3). The upper ball joint is preloaded by a rubber spring. The load and rate of this spring keep the stud engaged with the bearing at all times. The bearing has grease grooves on top and on the inside diameter to provide lubrication for free steering action.

The lower ball joint also utilizes a bearing with grease grooves. This joint supports the weight of

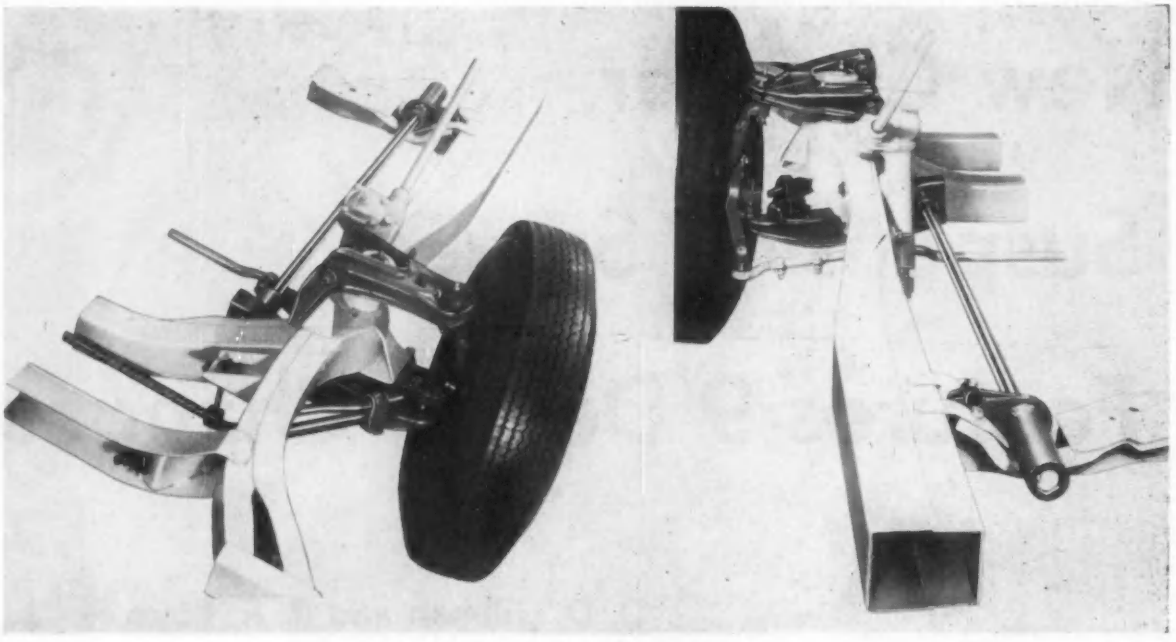


Fig. 1—Front suspension, front and rear views.

the car. Hence, it isn't necessary to preload this bearing since there is no reversal of load.

The inner pivots, straddle-mounted rubber-shouldered bushings, use the double-shear principle on their mounting bolts. Each bushing attaches to the frame by an inner pivot stamped bracket. A stack of 1/16-in. shims separate it from the frame. With a ball joint outer pivot, wheel caster and camber can be adjusted by adding or subtracting the proper number of shims under the front or rear control arm bracket.

A rubber idler arm bushing and nylon bearings in the ends of the transverse steering link provide less friction at these points.

The net result is steering effort about equal to previous models.

4. Road Noise

Isolating the front suspension from the frame by rubber at every point of contact reduces transmission of road noise into the car. The lower control arm consists of the load-carrying arm and the front strut. The pivot point of the strut lies on the inner axis of the lower control arm. The front attachment is a large mass of rubber that forms a pillow on each side of the inner front frame member. Rubber also isolates each of the additional attaching points of the suspension and the frame.

5. Directional Stability

Roll understeer counteracts the loss in roll steer due to the increased roll stiffness. It also offsets the increased rear tire slip angle caused by a greater percentage of the roll couple taken at the rear.

A neutral toe pattern proves the best compromise for cornering ability and directional stability.

The caster is increased over that of previous models. Manual steering cars are changed from -2 to $-\frac{3}{4}$-deg and power steering cars from 0 to $\frac{3}{4}$-deg positive caster.

Wider rim widths increase tire lateral stiffness.

6. Breaking Dip and Acceleration Squat

Antibraking dip and antiacceleration squat depend on design of both front and rear suspensions. The elimination of braking nose-dive is done by the diversion of the braking forces through the use of an inclined upper control arm to the chassis. The rearward braking force divides into a horizontal braking force to stop the car and a vertical force to lift the car. This provides a lifting component on the front suspension to offset the weight shift. Fig. 4 shows the antidip braking principle of load application.

7. Maintain Uniform Car Heights

Height adjustment of the front suspension is achieved by winding up the torsion bar. This permits rapid adjustment in the field if the springs should settle.

The rear of the torsion bar is fixed in an anchor housing that is cradled in the engine rear frame cross-member. The adjustable height feature of

the torsion bars insures uniform front-end car heights as the cars come off the assembly line and permits further field adjustment if necessary. Torsion bars also permit more exact transferring of the loading point of the suspension to the portion of the frame structure which can best handle these loads. Hence, design of high-production torsion bars keeps operating stresses down and permits normal automotive production methods.

8. Lubrication

Front-end lubrication points have been reduced from as many as 23 to 8—four tie-rod ends and four ball joints. Rubber bushings play an important part in eliminating lubrication fittings by replacing the metallic joints which require lubrication.

9. Flat Ride

A more balanced ride has been obtained through better spring balance front to rear, higher radius of gyration, and better balanced shock-absorber control. Minimum roll angle results from:

1. Lowering the center of gravity 1 to 3 in.
2. Increasing front roll stiffness 30%.
3. Increasing rear roll stiffness 35%.

(Paper, "Chrysler Torsion-Aire Suspension—Across the Board," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

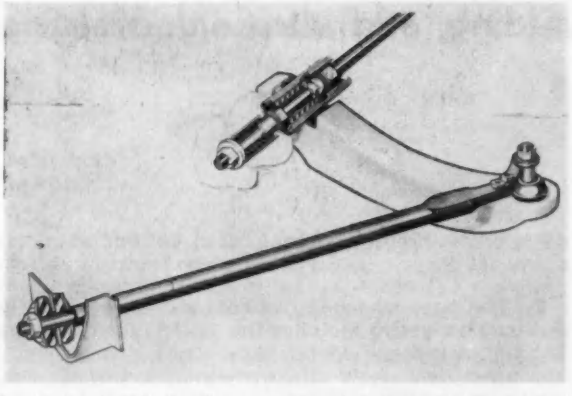


Fig. 2—As the wheel strikes an object, the wheel and lower control arm assembly retreats to the rear approximately ⅛ in. to reduce the gravity force buildup. The strut has a forged rear end that allows the proper metal section to carry offset loads around the corner to the 2-bolt attachment and provides a permanent wheel stop.

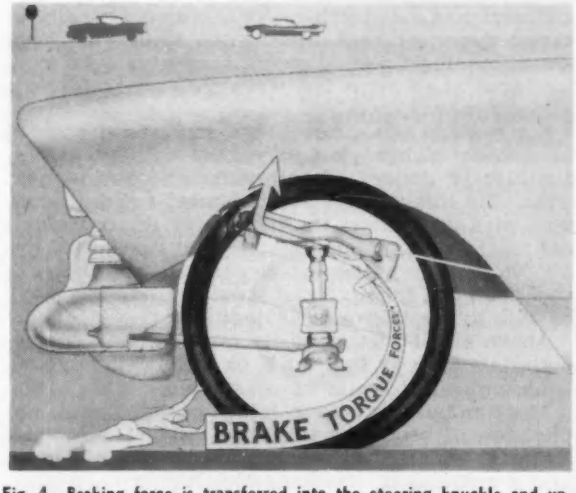


Fig. 4—Braking force is transferred into the steering knuckle and upward to the ball joint of the upper control arm which is inclined 17 deg to the horizontal.

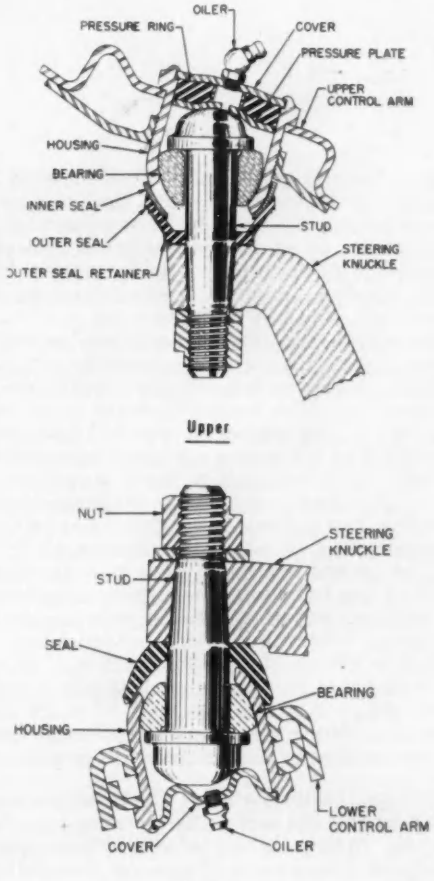
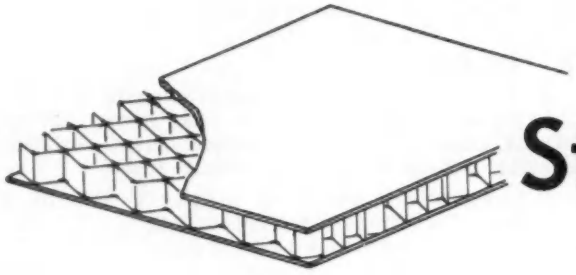


Fig. 3—Front suspension ball joints. They show the rubber spring loading member in the upper joint as well as the permanently lubricated bearings.



Steel Sandwich To Highlight

Adhesive bonds, brazing, spotwelding, and ultrasonic welding

THE skin-heating problems associated with flight at Mach 3 or faster necessitate steel skins rather than aluminum. To take full advantage of high-strength steels, skins will probably be of sandwich construction. Attachments will very likely employ adhesive bonding, brazing, spotwelding, or ultrasonic welding—and not rivets or bolts.

Several major aircraft companies are playing with the idea of designing a new generation of fighter-interceptor planes which will be capable of better performance in more severe thermal surroundings, at least for a limited time. So far, however, the practicability of protective measures against the intense heat of the boundary layer is unproven for flight at high Mach numbers. Without insulation and cooling, the temperatures developed in the surface structure of an aircraft traveling at the contemplated speeds will be so high that the material strength of the light alloys would be unsatisfactory.

The replacement of aluminum with denser materials having better heat-resisting qualities seems unavoidable. Some of the new super steel alloys are rather attractive in this respect and will probably be used before titanium because of more assured availability. The high-strength corrosion-resistant steels can be divided into three main groups:

1. **The austenitic stainless steels which are represented by the 300 series:** These alloys are usually called the chrome-nickel steels. They are most widely applied because of their good formability and their hardness can be increased by cold working. Their tear-resistance properties are quite good, but even with full-hard temper the compressive yield is less than 150,000 psi. Exposed to elevated temperatures they show excellent resistance to oxidation and corrosion, while their strength and stiffness deteriorate rapidly when heated to temperatures above 800 F.

2. **The age- or precipitation-hardening stainless steels:** This group includes the 17-7 types, Stainless W, and Allegheny Metal 350. They are basically chrome-nickel steels which are modified by the addition of small percentages of other elements, like aluminum, molybdenum, and titanium. These modified alloys respond readily to heat-treating procedures.

3. **The straight chromium corrosion-resistant steels which are found in the 400 series:** These alloys are martensitic or ferritic. They respond readily to varied cycles of heat treatments, similar to most low-alloy steels. As a group, they give good performance at elevated temperatures.

For surface skins, new alloys must be developed to provide higher yield strengths without loss of ductility or danger of embrittlement during heat treat. By combining a relatively high carbon content with 2% silicon the makers of Super Tricent are reaching for a compressive yield strength above 300,000 psi. Only the future can tell how much of this potential strength the structural engineer will be able to use in practical design.

Above 800 F better heat-resistant, but costlier materials such as Inconel X or molybdenum (0.5% titanium) will have to be considered.

Mention has been made, lately, of the possible application of beryllium to aircraft structures. This material, which has the same density as magnesium and a modulus of elasticity 50% higher than steel, has great potentials for alleviating some of the thermal problems associated with high-speed flight.

Based on paper by **Alf Fridtjof Ensrud,** Research Specialist, Lockheed Aircraft Corp.

Structure

New Fighter Aircraft

are probable means to the practical joining method needed.

Beryllium, however, is scarce, toxic, and extremely brittle. If these obstacles could be overcome, beryllium compression panels employed in aircraft surface structures would save about 50% of the weight of present materials.

The problem of brittleness is attracting increasing attention from aircraft designers. The tear resistance of an alloy has become an important property to be considered in the final selection of a material. As a rule, the comparison of different metals, in this respect, is based on the response of a specimen containing an initial crack to tensile loading. Such a comparison for presently available materials is shown in Fig. 1. The critical crack length is related to the maximum gross area stress a damaged panel can sustain. The specific gross stress is obtained by dividing this value by the density of the material. Note that Allegheny Metal 350 has far superior tear resistance than highly heat treated 420 steel, however its yield strength at 600 F is not very impressive.

Fatigue problems do not seem to be aggravated much by the thermal environment encountered in high-speed flight. Since the fatigue strength of most aircraft materials decreases more slowly at elevated temperatures than their static strength, structures which are adequate fatigue-wise at room temperature should remain so in thermal surroundings.

Creep is a phenomenon which, up to this time, has not plagued the aircraft engineer very much. Only recent designs will be capable of flying at speeds where aerodynamic heating increases the temperature of the airframe to such an extent that creep might have to be considered.

Creep is the time-dependent plastic deformation of a metal subjected to heat and prolonged loading. It can occur under tension, compression, bending, shear, and combined stresses. Creep can become a very important factor in the life of supersonic interceptors whose flight missions frequently include a speedy acceleration to high Mach numbers, a supersonic dash, followed by rapid decelerations. Care must be taken that after such maneuvers no plastic deformations of appreciable magnitude remain in the supporting structure which might progressively accumulate and result in a sudden catastrophic failure.

The evaluation of the effects of creep in an assembled structure is a very complex problem due to the high redundancy of aircraft components. A procedure similar to that used in testing the fatigue life of a structure might recommend itself.

It may be, however, that the effects of creep will be significant only in rare cases for aircraft designs contemplated for the immediate future due to intrinsic stress relaxation within the structure.

Sandwich Panels

Recent developments have shown that by proper alloying and the use of improved heat-treat cycles some steels can be processed to much higher strength than is customary today. Laboratory research indicates that the increased strength is not necessarily associated with dangerous brittleness and that in the not too distant future satisfactory sheet stock may be available with a guaranteed minimum tensile strength exceeding 350,000 psi. But how can the aircraft designer take advantage of this large increase in strength? The possibility of weight savings in forgings and fittings is obvious. However, about 60% of the structural weight of the

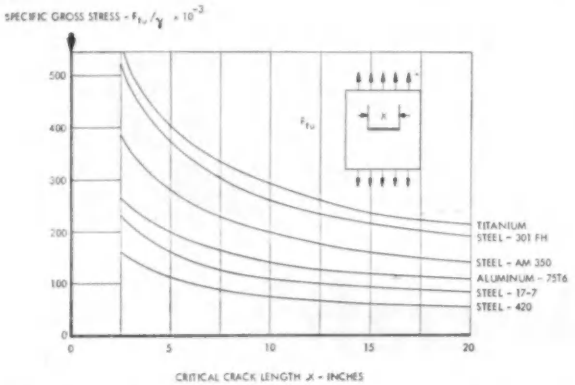


Fig. 1—Tear resistance of presently available materials. Comparison is based on the response of specimens containing an initial crack to tensile loading.

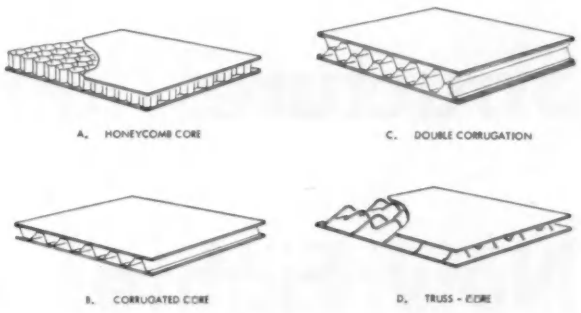


Fig. 2—Typical sandwich configurations.

airframe is absorbed by the surface panels of the fuselage and wings, and these have to be properly stabilized before they can be subjected to extreme compressive loading.

Usually, the load indices for the surface structure of aircraft components are rather low, resulting in thin gages for the skin panels. Conventional structures with stringers or ribs spaced sufficiently close to realize maximum compression allowables are likely to prove either costly to make or be impracticably heavy. In fact, their weight becomes prohibitive when dealing with the thin skin gages associated with the ultra-high-strength alloys. One way to overcome the higher density of heat-resistant materials is through sandwich construction. This construction permits the load-carrying material to be distributed such as to provide optimum strength and stiffness for a given weight.

The two principle design configurations being considered for thermal flight have either cellular cores or corrugated cores. The cellular cores are formed from thinly rolled metal foil of 17-7PH steel or similar alloys welded together at the cell nodes. The bond between core and facing is achieved by furnace brazing or resistance welding.

The corrugated cores consist of thin sheets formed in sinusoidal or trapezoidal shapes. As shown in Fig. 2, this type of core may be used in one or more tiers and, at times, is preferred because the corrugations contribute to the load-carrying area of the panel.

A recent innovation in sandwich construction, known as Truss-Core panel, is also shown in Fig. 2. It consists of two face sheets stabilized by a core of interlaced truss-shaped wires. The individual wire trusses forming the core matrix are spaced about 1 in. c to c in the longitudinal and transverse direction and are furnace brazed to the facings.

Sandwich panels are ideally suited for high-performance aircraft since they preserve an accurate outside contour and are not given to quilting under pressure loads. Weight-wise, a sandwich panel has a large effective thickness due to the low density of the core and thus needs fewer internal supports, making it a better enclosure for fuel compartments. Optimum-design studies indicate that it is advisable to use a minimum of supports and to determine the lowest core density which will attain the compressive yield stress in the face sheets. The cell size must be small enough to prevent local buckling of the facing within the confines of the cell boundaries. Good bonding between core and facing should at the least be able to realize compressive yield stresses in the surface skins. Higher loadings in the surface skins usually result in failures, with the sandwich facings buckling into the core by forming a transverse wrinkle.

The major advantages of steel sandwich panels are:

1. The possibility of stabilizing thin sheets at very close intervals in an efficient manner, thus realizing high compression allowables in the facings without the addition of excessive parasitic weight.
2. High weight-strength ratio.
3. Smoothness and rigidity in the finished assembly.
4. Excellent fatigue characteristics.

In spite of their many good points, the theoretical potentials of high-strength steel sandwich panels have not been fully exploited due to:

1. Fabrication difficulties.
2. Lack of adequate facilities and production know-how which would guarantee the structural integrity of the final product. Brazing furnaces are too small to accommodate large panels and little success has been

made in fabricating any but the simplest configurations at reasonable cost.

3. Excessive cost of manufactured panels. Present quotations run anywhere from $150 to $1500 per sq ft prior to installation for brazed or resistance-welded steel honeycomb panels.

4. The complicated details required at splices and points of attachment. Satisfactory solutions which will insure reliable load transfer at these points have yet to be devised. Present designs are usually too costly, too heavy, or impractical in meeting close tolerances. In making weight estimates of panels, it is necessary to add between 40% and 80% of the facing weight for splices and attachments.

5. The questionable quality of the bond between core and facings. While tests have shown that it is possible to realize yield strength or even higher allowables in the facing material of brazed sandwich panels, a report issued by the Forest Products Laboratory indicates an alarming inconsistency in the failure loads of test specimens. It seems that out of a series of 12 specimens only one gave satisfactory results, while several others failed at much lower loads, one as low as 15% of the predicted strength.

High-strength steel sandwich panels, adequate for highly-loaded primary applications, are still in the experimental stage. Extensive research and development programs are required before complicated sandwich configurations can be incorporated in actual production designs. For the time being, it seems that other, maybe less efficient but presently available, configurations such as machined waffle grids or chem-milled panels will have to be used.

Some of the new super alloys tend to become rather brittle when subjected to severe heat treats, especially after intimate contact with various brazing alloys. Extreme precaution must be taken, therefore, to ensure fail-safe designs. How critical this situation actually is can be vividly demonstrated by an incident which occurred during a recent wing-box beam test. The test specimen was made of 420 corrosion-resistant steel and the surface panels were stiffened by J stringers brazed to the skin at 1.5 in. spacing. A small rivet hole, which for some unknown reason was punched through the .025 gage web of one of the stringers, precipitated failure of the whole tension panel at an applied stress of only 50,000 psi.

Skin panels reinforced with waffleized Unicore sheets, on the other hand, show a high degree of tear resistance. Some test panels containing a 4-in. crack developed the ultimate tensile stress of the material due to Unicore-sheet backing.

While Unicore panels are not as efficient in overall strength and stiffness as true sandwich panels, their economical fabrication and easy assembly recommend them for application.

Thin Wing Structures

Of foremost interest in the design of future fighter aircraft is the possible application of heat-resistant alloys to wing surface structure. While many types of design configurations are suitable for wing struc-

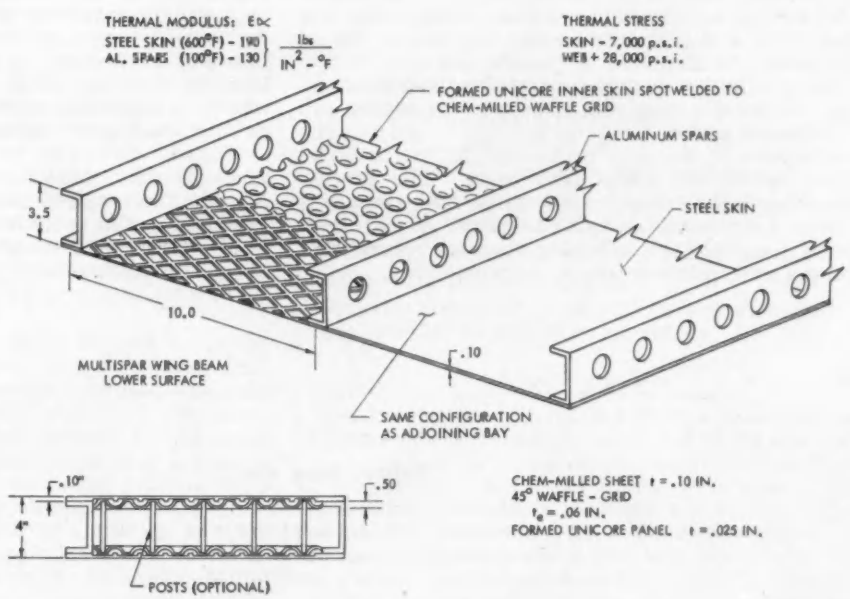


Fig. 3—Typical Unicore design configuration. By combining a chem-milled waffle grid with the Unicore panel, the interattachment buckling stress in the skin panel is greatly increased.

ture of subsonic airplanes, in thermal flight the choice should be limited to the following surface configurations:

1. Integral panels, machined or chem-milled.
2. Sandwich panels, brazed or resistance welded.
3. Face-to-face stabilization by cellular cores or truss cores.
4. Unicore construction.

A typical Unicore design configuration is shown in Fig. 3. By combining a chem-milled waffle grid with a waffleized Unicore panel, the interattachment buckling stress in the skin panel is greatly increased, making the overall efficiency of the surface structure very attractive. Furthermore, the use of aluminum spars provides additional weight savings by reducing the transient thermal stresses. Assuming instant accelerations to Mach 3 and neglecting probable reductions due to the high diffusivity of the light-alloy spars, the maximum thermal stresses reached during the transient stage are conservatively estimated at the values shown in Fig. 3. Actual tests have proven that the fail-safe characteristics of Unicore construction are far superior to those of conventional design.

Methods of Attachment

Since steel is stronger than aluminum, thinner gages will be used. This means greater stress concentrations around rivet holes. Thermal redundancy results in the transfer of appreciable shear forces across the surface-structure web junctions, in addition to the thermal stress buildup along the length of riveted joints. If small-diameter rivets of low shear strength are used to join heavy sections, the thermal stresses alone may cause rivet failure.

No wonder an increasing number of engineers feel that rivets and bolts are on the way out as far as thermal-flight airplanes are concerned.

One possibility in this area is adhesive bonding. The process is simple and satisfactory bonding can be achieved at low temperatures thus reducing the possibilities of warpage or change in the material properties of the component parts. The process also permits the joining of dissimilar materials, providing an automatic safeguard against galvanic corrosion. In addition, adhesive bonding is leakproof and not susceptible to stress concentrations.

Adhesive films must be developed to withstand the high temperatures associated with thermal flight. Post-cured epoxy resin adhesives show fair bond strength up to 250 F. Lately-developed adhesives give promise of 50% room temperature shear strength at 650 F.

In spite of the problems associated with intense furnace heating and subsequent cooling, brazing appears to be the answer to the fabrication of many types of sandwich panels. Theoretically, the process is very attractive, however many practical problems remain to be solved. This type of assembly requires careful production and inspection control. Separate departments have to be established where the process can be carried out with clinical cleanliness. Workmen must wear gloves and each individual part should be protected against possible contamination. After assembly, the continuity of bond must be ascertained by 100% radiographic inspection. Present plans to start large-scale facilities and experimental operations should be successful in solving many of these problems.

Spotwelding is the cheapest method of joining steel sheets provided proper equipment and monitoring during the process reduces required radiographic inspection to less than 10% of the spotwelds. Unicore construction lends itself very well to this process. Resistance-welded sandwich panels, however, must still be considered in the experimental stage. The greatest deterrent to their success, at present, is the high cost of proving the structural integrity of new configurations.

Ultrasonic welding is a method for joining similar or dissimilar metals by introducing elastic vibratory energy into the area of the components to be bonded. The metallurgical bonds produced by this process give the same order of shear strength as the older technique of high-pressure welding. Ultrasonic welding requires no heat and uses lower applied static compression. Hence, the resulting deformations at the surfaces, where the pressure is applied, are relatively small. The internal plastic flow which occurs during the process at the interface and the absence of heat during welding reduce local brittleness. And, surface cleanliness is not nearly as important in obtaining a satisfactory bond as with resistance welding.

(Paper, "Problems in the Application of High Strength Steel Alloys in the Design of Supersonic Aircraft," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Where Does the Oil Go?

■ *We find that of the total oil consumed in current production passenger cars, as much as 75% disappears via valve stems and guides. Surprisingly enough exhaust valves are often almost as great contributors as intakes.*

—Arthur M. Brenneke, Perfect Circle Corp.

Continental Develops Turbocharged Aircooled Diesel for Tank Installation

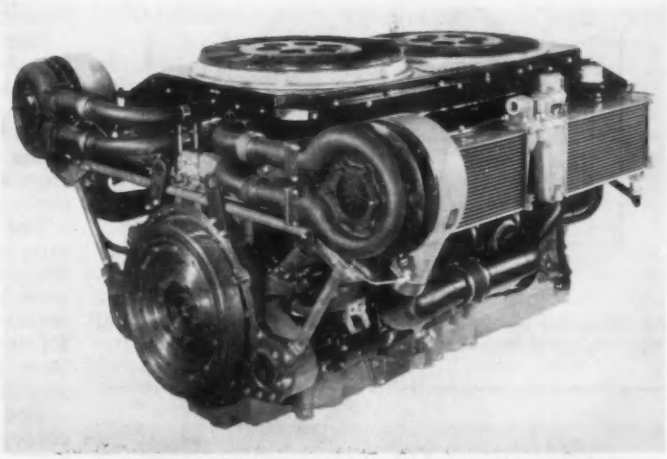


Fig. 1—Continental 750-hp aircooled diesel seen from flywheel end.

Based on paper by **Dr. Herbert H. Haas and Earl R. Klinge,**
Continental Aviation and Engineering Corp.

A 750-hp turbocharged, aircooled diesel engine has been developed for the M-48 tank. It has the same net installed horsepower as the gasoline model it is intended to replace, yet uses 40% less fuel (Fig. 1).

The new AVDS-1790, as the engine is designated, follows the basic configuration of its gasoline predecessor, the AV-1790, thus insuring a minimum of vehicle changes to accommodate it and making possible retrofit installations. It is a 12-cyl, 90-deg V, with bore and stroke of $5\frac{3}{4} \times 5\frac{3}{4}$ in. and 1790 cu in. displacement.

The cylinder spacing is 9.00 in, or 1.56 times the bore. This ratio is dictated by the required uniformity of the cylinder dome wall structure and by the necessary cooling fin area in between the cylinders. Likewise, this spacing permits use of large counterweights on the crankshaft so that reactions of the heavy reciprocating parts are reduced to a negligible size.

"Mexican Hat" Combustion Chamber

The combustion system is of the 4-stroke direct-injection type with an open quiescent combustion chamber. It has the so-called "Mexican hat" shape and is formed by the piston crown. The advantages of this type of combustion chamber are:

- High performance potential.
- Minimum fuel consumption.
- Suitability for exhaust turbocharging.
- Good cold start. (In this instance, cold start down to – 25 F without external aid.)
- Low heat rejection to cylinder and piston.
- Uniform thermal loading.
- Good breathing capacity, particularly with a dome cylinder head and angle valves.

Aircooling System

Suction cooling is employed for the basic purpose of surrounding the engine and fuel tanks with the incoming cold air. The hot discharge air is confined to a relatively small duct in its path toward discharge from the vehicle. A slight penalty on cooling fan size is endured since the cooling fans must handle the less dense hot air. On the other hand, the circumferential temperature distribution around the cylinder is more uniform with suction cooling than with pressure cooling (Fig. 2).

Besides oil coolers for the engine, the torque con-

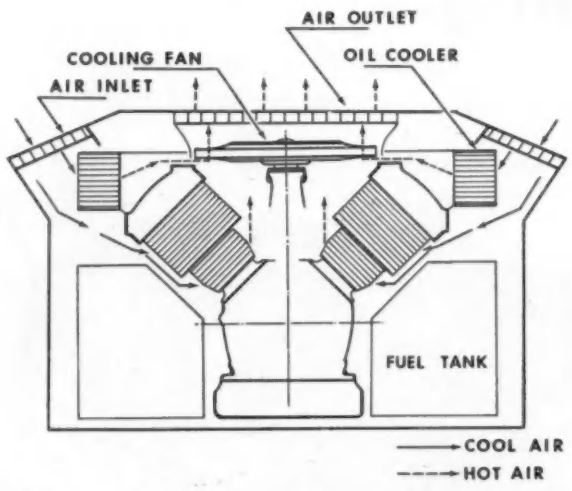


Fig. 2—Suction cooling is used in preference to pressure cooling in order to surround engine and fuel tanks with incoming cold air.

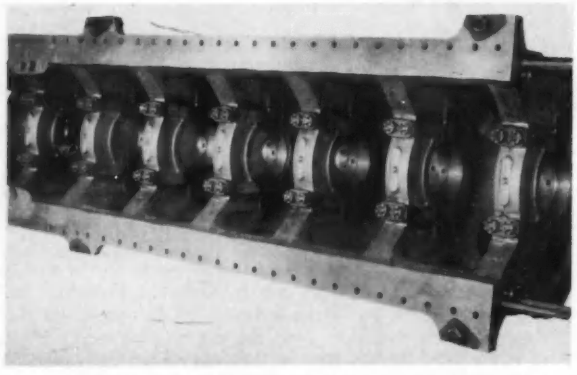


Fig. 3—Crankcase of Continental AVDS-1790 is rugged one-piece cast-aluminum structure of Alcoa 355 with forged aluminum main bearing blocks.

Fig. 4—Deep-finned cylinder, connecting rod, piston assembly, and hold-down spring used to avoid overloading the nozzle gasket and compensate for differential expansion between aluminum and steel.

verter transmission coolers are mounted on the engine and cooled by the engine fans. This results in considerable space saving over separate fans for each cooling function. The torque converter transmission cooling poses a problem in off-road operation. A large portion of the engine horsepower might have to be dissipated through the transmission oil coolers if the vehicle is operated at full throttle but nearly stalled in mud. On the AVDS-1790, transmission oil cooling is provided for a heat rejection of one-third of the net engine output.

Airflow restriction presented by bullet-proof grilles for admission and discharge of the cooling air adds considerably to the required cooling fan power. Consequently, the total fan power amounts to nearly twice the fan power needed for the engine cooling alone. Two 26-in. axial fans, mounted on top of the engine and driven at twice engine speed, satisfy all cooling requirements.

The crankcase is a rugged one-piece cast aluminum structure of Alcoa 355, with forged aluminum main bearings blocks (Fig. 3). Special attention has been paid to the shape of the various crankcase sections to minimize stress concentration and deformation under load. The contours of the crankcase are smooth and without ribs. Short and straight stress paths are provided.

The crankcase extends far below the crankshaft centerline and the cast aluminum oil pan is made a part of the structure. Thus, a stiff beam member is obtained which compensates for the small total crankcase height, which is characteristic for air-cooled engines.

Crankshaft and Bearings

Because of the anticipated high output ratings, demanding the use of peak combustion pressure between 1600 and 1800 psi, and because of the need for torsional and bending rigidity of the crankshaft, a main journal size of 4.25 in. and a crankpin size of 3.75 in. were selected. Width of the cheek is 1.6 in. Integrally forged, crankshaft counterweights were provided for approximately 85% balance. This was done to reduce the internal forces trying to break the engine in the middle.

The crankshaft is forged from SAE 4340 Ni-Cr-Mo-Mn steel and nitrided. Both main and connecting-rod bearings are copper-lead, backed with rather heavy steel shells, 0.250-in. thick in the case of the main bearings. Main bearings have a width of 2 in., while the connecting-rod bearings are 1.35 in. wide.

The connecting rod, of conventional design, is forged from SAE 4140 Cr-Mo-Mn steel and fully shotpeened. The roundness of the big end bearing is maintained over a wide variation of load and of the torque applied to the connecting-rod bolt, thus permitting full utilization of the bearing capacity. Fig. 4 shows the connecting-rod together with other related components.

Cylinder Unit Features

The cylinder head is an aluminum casting of Alcoa 142-T75 Cu-Ni alloy and its main design fea-

tures are: overhead camshaft, 2-angled valves, simple cooling fin, and injection nozzle installation with a high degree of accessibility. The valve plane is shifted slightly off center to permit nozzle assembly removal from the top.

The combustion-chamber-dome shape represents a compromise between the conflicting desires for a large radius dome for minimum stress and a sharp cornered dome which would permit an increase in piston length and reduce the piston crown area exposed to combustion.

The cooling fins are set on the cylinder head at an angle of 30 deg and reach from the intake to exhaust side of the head. This gives ample cooling fin area, but gave some trouble in the casting operation. The cooling performance of the cylinder is outstanding, with a maximum head temperature of 350 F at 750-hp output at 6 in. of water pressure drop across the cylinder. This together with the satisfactory functioning of the injection nozzle is attributed largely to the cooling condition.

The cylinder barrel is made of 8740H Cr-Mo-Mn steel and is screwed and shrunk into the cylinder head while the head is heated. Valve seats and guides are shrunk into place at the same time. The intake and exhaust valves and seats are fabricated from a common silicon-chrome valve steel, there being no need for expensive alloys with the low exhaust temperature of the diesel cycle. It has been found desirable to face the intake valve seat with stellite to prevent wear. Apparently, seat wear occurs because of the completely dry inlet valve operation in a supercharged engine.

Lubrication System

To satisfy very definite requirements, the lubricating system consists of two circuits—main circuit and piston cooling circuit—which are operated independently but fed by one multiple pump (Fig. 5). The main pressure pump draws its oil from a compartment in the oil pan, which is fed by a twin scavenge pump from both ends of the engine. The oil is forced at a maximum quantity of 50 gpm through the engine oil coolers, then through a full-flow filter, and thence through the engine oil galleries to the bearings. A pressure regulator is influenced by the pressure in the main bearing gallery and dumps the surplus oil unfiltered back in the pan. A small partial flow is split off after the main filter and fed through a second full-flow fine filter to the exhaust turbochargers and the fuel-injection pumps.

The piston cooling oil circuit is separated from

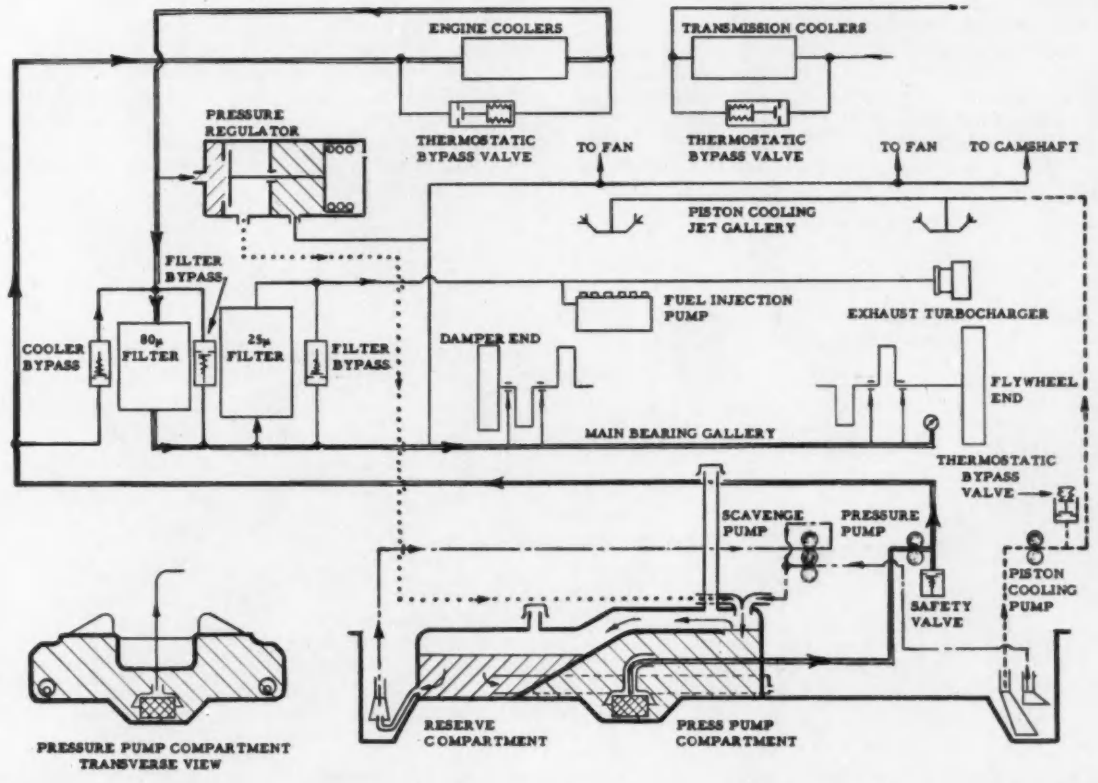


Fig. 5—Lubricating system has two circuits, a main circuit and a piston-cooling circuit. Operation is independent, but both are fed by one multiple oil pump.

the main lubricating system for three reasons:

1. To reduce the oil filter size by preventing cooling oil from flowing through the filters.
2. To reduce undue power loss by means of bypassing the cooling oil, if cold.
3. To divide the oil flow in view of the high total of nearly 70 gpm.

The piston cooling pump picks up the oil from the open end of the pan at appropriate level and delivers it to oil jets at the rate of 20 gpm. These jets are located at the bottom of each cylinder and provide a continuous oil spray to the inside of the piston. A thermostatically controlled bypass valve opens at an oil temperature below 140 F and dumps the oil flow of the piston cooling pump directly back to the sump, thus preventing unnecessary power loss at the other than high load condition.

Lube oil filters and control valves are all accessible from the front end of the engine. A wire mesh filter of 80 micro-mm and a paper fine filter of 25 micro-mm are arranged in series to prevent the latter from becoming loaded with particles of a size greater than 80 micro-mm. The wire mesh filter feeds the main oil galleries while the paper filter feeds the turbochargers and injection pumps.

Fuel-Injection System

Two conventional in-line, 6-cyl American Bosch APE 6BB injection pumps with 12-mm plungers produce desirable injection characteristics from 600 to 2600 engine rpm. The central location of the injection pumps makes possible uniform and short injection lines a decided asset on a high-speed engine.

A special nozzle has been developed, but contains a standard American Bosch ADB type nozzle with eight holes of 0.3 mm.

A positive-displacement fuel delivery pump, mounted on top of the gear drive for the generator, delivers fuel to the injection pumps at a pressure of 25 psi at a rate of 200 gph. This high pressure and delivery rate has been chosen to prevent vapor formation in the event the engine is operated on JP-4 or kerosene.

The automatic timing unit is located ahead of the two injection pumps. A hydraulic vane type is under development, but where torque varies as the square of the speed, a timing change with load will probably satisfy the engine.

Dual turbochargers are provided because of space and package limitations. They are located outboard of the engine at the flywheel end, one on each side, and are aircooled.

In the AVDS-1790 an attractive specific weight and bulk has been achieved with 5.0 lb per hp bare engine and 10.0 gross hp per cu ft of installed unit-cooled power package. Actually, the 750-hp bare engine rating provides the same net installed power as the 825-hp unsupercharged gasoline engine by virtue of three items:

1. The engine heat rejection is less than the gasoline engine and the cooling power is thus smaller.

2. The turbocharged engine requires no exhaust muffler, hence there is no loss from that source.

3. The turbocharged engine power is not primarily affected by induction air cleaner losses since the turbocharger merely operates at a slightly higher pressure ratio.

A full load power curve is shown in Fig. 6 while a fuel consumption map is presented in Fig. 7.

(Paper, "The Continental 750-Horsepower Air-Cooled Diesel Engine," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

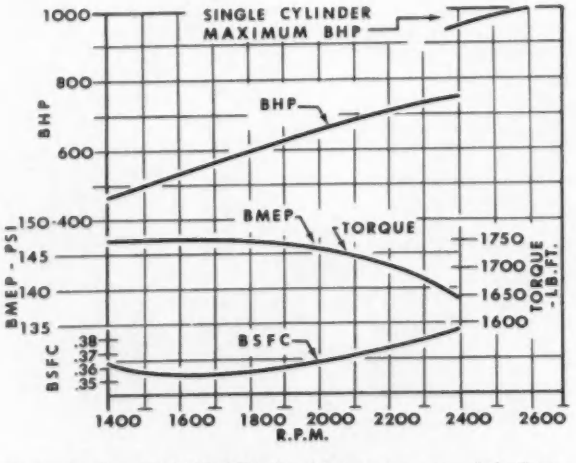


Fig. 6—Continental AVDS-1790 diesel has met or exceeded all performance expectations. Rated performance was produced within a week of its green run.

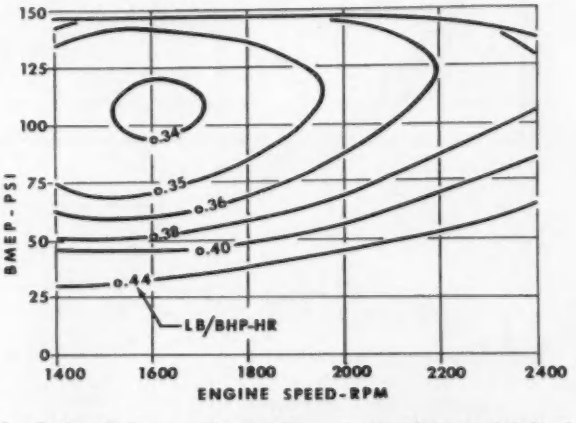


Fig. 7—Low fuel consumption justifies contention that aircooled diesel might be superior to gasoline engine. Logistic fuel problem creates need for reduced fuel consumption and increased vehicle range.

Steps on the way to Ford's production version of its

Automatic Retractable Hardtop

Based on paper by **B. J. Smith,** Lincoln Division, Ford Motor Co.

THE first model made on the way to Ford's final production design for an automatic retractable hardtop had only one drive motor and a master cycling switch. The production version uses three drive motors and four lock motors.

In the production version, the control system is sequentially operated. That is, a switch, located at the end of each component's travel, signals the stopping of that component and the starting of the next.

Along with the seven motors, other components include 10 solenoids, 13 switches, and, for safety purposes, 9 circuit-breakers. The special wiring harness includes 610 ft of wire.

The final design meets all the original concepts. These include:

- Use of an existing prototype car with minimum changes in its sheet metal.
- Completely automatic operation.
- Single pushbutton control.
- A 6-passenger seating arrangement with full-width rear seats.

The first of many experimental steps in reaching the production design was to examine the 3/8-size working model of a retractable-top design Ford had developed, but never produced, some time ago. A mechanical sketch of this early prototype is shown in Fig. 1.

IN THIS EARLY PROTOTYPE, the forward edge of the deck lid was controlled by the roof drip rail, as the roof was being retracted by a drum and cable on a track assembly. The back light was separated

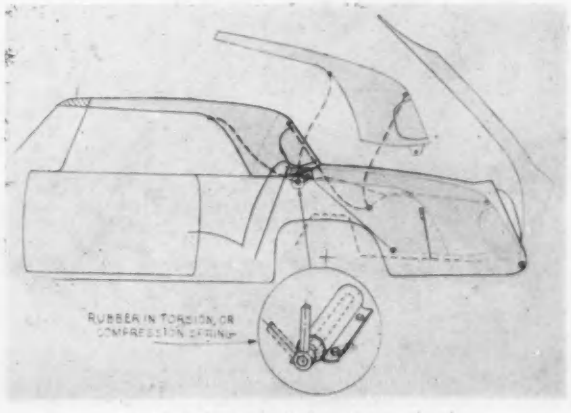


Fig. 1—Early mechanical prototype sketch.

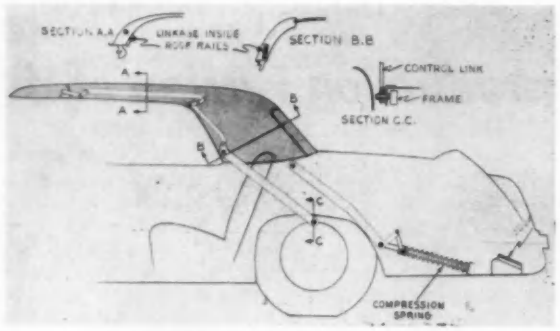


Fig. 2—Continental retractable linkage.

Fig. 3—Early working model of Fig. 2 design.

Fig. 4—Retractable with top up.

Fig. 5—Retractable roof in operation.

from the roof to permit easier roof storage. . . . While workable, this design presented several major problems. A more simple method to retract the roof was necessary, for one thing. The large header section that remained with the windshield was undesirable, too.

THE ENTIRE LINKAGE IS CONCEALED within the roof rail section in the later design shown in Fig. 2. This design incorporated a general idea of how it was felt the goal could be accomplished.

The forward portion of the roof folded under the rear portion as the roof was being retracted. The two main links were the only connection between roof and body. When power was applied to the forward link by an electric screw jack, the rear link acted as the control link, since it controlled the path of roof travel.

A ⅜-SIZE WORKING MODEL of the Fig. 2 design is shown in Fig. 3. This was made to speed the project. Unique features were a retracting back light and double deck-lid hinging (deck lid hinged at the rear to store the roof and at the front to load luggage). The working model emphasized the complexity of these features. So, they were eliminated from the final design. There the retractable deck is hinged from the rear only.

Another early type of control that was abandoned was a control circuit incorporating a master drum-type cycling switch (similar to that used on automatic washers). The cycling switch was geared directly to the drive motor, which was rated at 200 in.-oz, and which, with suitable gears, clutches, and flexible shafts, powered all driven components. A simplified system of integration was later developed.

THE OPERATING SEQUENCE is shown in Figs. 4, 5, and 6. Notice the shelf panel which was hinged at the rear of the seat-back panel, and the wings which folded down to clear the roof linkage when the roof was up.

To eliminate the necessity of folding the wings and to simplify the design, the shelf panel is hinged on the forward edge of the deck-lid in the production design.

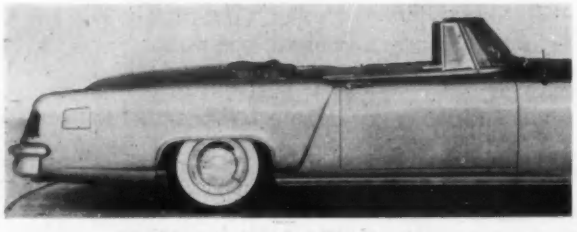


Fig. 6—Roof retracted into trunk.

THE FIRST FORD RETRACTABLE PACKAGE and how it differed from the regular Ford Fairlane is shown in Fig. 7.

Overall length was extended 3 in. to 210 in., rear-passenger leg room was decreased 2.5 in., and the roof panel at the centerline was shortened by 3.75 in.

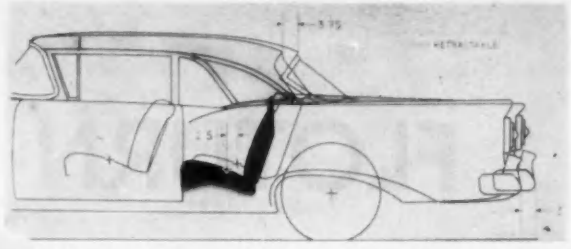


Fig. 7—How first Ford retractable package differed from Ford Fairlane.

A SPECIAL FRAME (with side rails pushed inboard to permit roof linkage clearance) is used from the kickup area back, as shown in Fig. 8.

The gasoline filler is located on the left side of the car, since a special divided gasoline tank is straddle-mounted over the driveshaft. This tank position permitted putting the spare tire in the usual tank position. The spare is mounted on a plywood board that serves as the floor of the luggage compartment. By use of a simple piano hinge, the tire can be pulled upward for easy removal over the quarter panel.

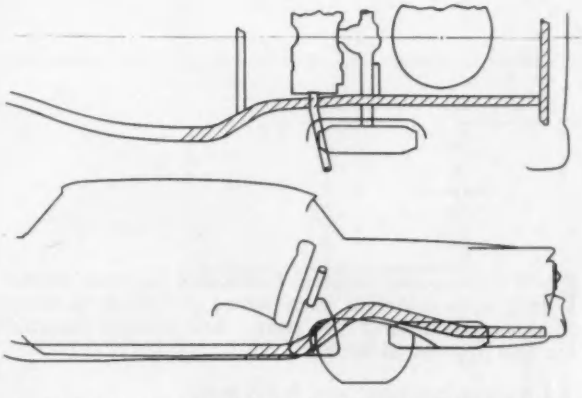


Fig. 8—Special frame, showing gasoline tank and spare tire location.

AN AUTOMATIC ELECTRIC HEADER LOCK designed to replace a hydraulic header lock which had been in the first retractable design, is shown in Fig. 9.

This design had a 2-in. diameter motor mounted at the centerline section of the roof header, and connected by flexible shafts to a worm and wheel transmission, which drives an acme-screw into a ratchet-type nut mounted on the windshield header.

THE RETRACTABLE OPERATION of the final design takes place in 10 steps, as follows:

1. The gear shift is placed in neutral position and the switch is pulled.
2. The deck-lid lock-motor unlocks two deck-lid screw locks.
3. When the deck-lid locks are three-quarters disengaged, the deck-lid drive-motor starts.
4. When the deck lid is fully up, a switch shuts off the deck-lid lock-motor and the deck-lid drive-motor, and starts the folding of the shelf panel.
5. When the panel is extended, a switch in the shelf-panel starts front and rear lock-motors.
6. When these locks are three-quarters disengaged, the roof-drive motor is energized and the roof begins to retract.
7. When the roof is 6-in. off the header, the roof-locks stop. (The front portion of the roof is being folded as the main linkage retracts the roof.)
8. When the roof is in its fully retracted position in the trunk, a switch cuts off the roof-drive motors and starts the deck-lid drive-motor and deck-lid lock-motor.
9. When the deck-lid locks are three-quarters engaged, the deck-lid drive-motor is shut off.
10. The deck-lid motor continues until the deck-lid is fully locked and the operation complete.

The potential importance of the retractable hardtop is indicated by the rapid increase in popularity of hardtops as a model. The hardtop style accounted for 31% of total automobile production in the first nine months of 1956.

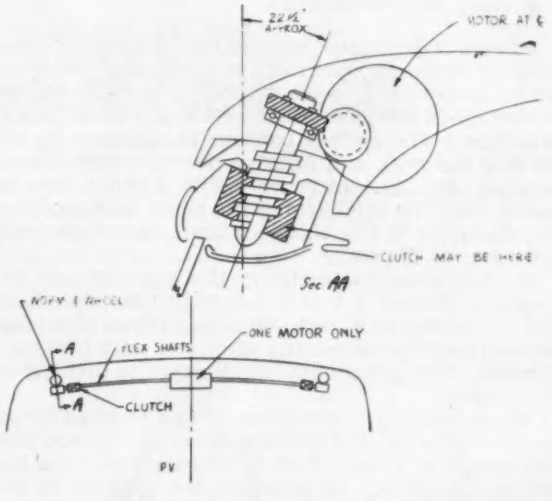


Fig. 9—Automatic header lock switch.

(Paper, "Birth of the Retractable," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

FLOTURN Shapes Metals

FLOTURN, a new chipless method of forming metal, displaces material in a spiral direction parallel to the centerline of the part. Advantages claimed for the process include:

1. Lower material and labor costs.
2. Close tolerances.
3. Elimination of welding.
4. Good surface finishes.

Floturn utilizes the cold-rolling techniques common to steel mill operation, but material displacement occurs in a spiral direction, parallel to the centerline of the piece, rather than in a longitudinal direction. The desired contour is achieved by revolving the work and forming over a mandrel with a roller (Fig. 1). In other words, *Floturn* obtains metal from the thickness of the blank and not from the diameter of the blank—a basic difference from spinning or drawing.

By displacing the metal in this manner, any increment of volume that is a specified distance from the centerline of a part will remain that same distance from the centerline after the part has been formed. This practically eliminates the problem of springback.

When forming a cylindrical section by the *Floturn* method (Fig. 2), the metal must be preformed into the shape of a cup. This is necessary because applying the theory of displacement parallel to the centerline of the part should result in a shear action on the blank if an attempt were made to displace it into a cylinder. Pressure is then exerted by the roller on the blank, which is backed up by a mandrel, causing the metal to flow into the desired configuration. Cost reduction can be obtained from the combination of drawing, machining, or welding with *Floturn*.

Fig. 3 shows some typical *Floturn* parts. On the left is a finished cone made from a flat blank. The center illustration depicts the advantage of using a short machined forging and the *Floturn* method to produce a part that has a greater depth and a much thinner wall. The illustration on the right shows a blank that is formed in a press and then *Floturned* through a series of operations to produce the final part.

Lower Material Costs

Floturn conserves material resulting in lower material costs. This can be a very handsome advantage with the high alloy materials which range in cost from 50¢ to $14.00 or more per pound. This reduction in material cost results from designing a part to be made from a shorter forging, a centrifugal casting, or from sheet or strip. In addition, when a part is properly engineered *Floturn* eliminates excessive labor costs as labor is not expended in producing chips.

The inherent ability of the *Floturn* process to form very close tolerance parts enables one to utilize this advantage to control the weight of the finished product. For example, a motor tube was formed by the *Floturn* method where the side wall or cylindrical section was held to .035 ± .001 in. Previously, the manufacturerer had not been able to maintain as close a weight tolerance on the finished product as desired for the simple reason that sheet could not be purchased which was consistently held within ± .001 in.

By the *Floturn* method it is often possible, especially in the jet engine field, to eliminate welding in a finished component, thereby eliminating secondary operations that accompany this weld, that is, the inspection, grinding, and certification of it.

In many instances, the finish of the *Floturned* product is such that the final polishing operation has been cut by 35–50%.

(Paper, "Shaping Metal by Flow Turning," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Based on paper by **C. L. Sporck and W. H. Busch,** The Lodge and Shipley Co.

Without Chips

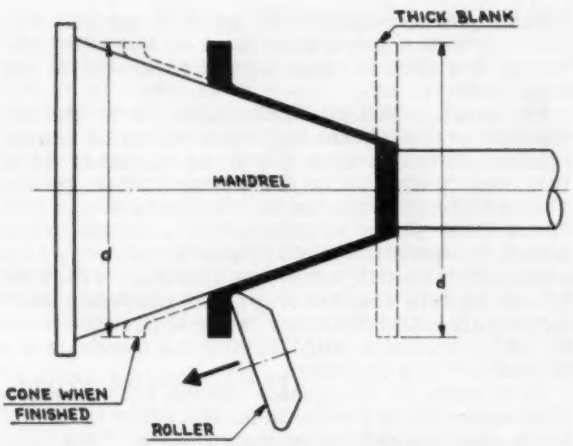


Fig. 1—In the "Floturn" process, the metal is shaped around a mandrel by a roller. Metal displacement occurs in a spiral direction parallel to the centerline of the piece.

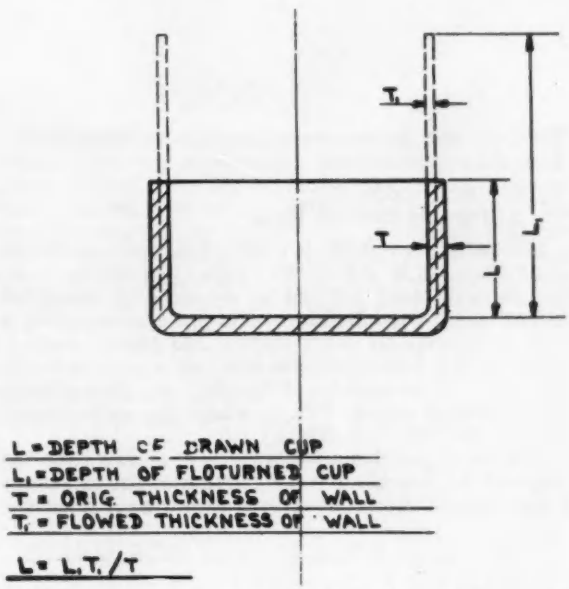
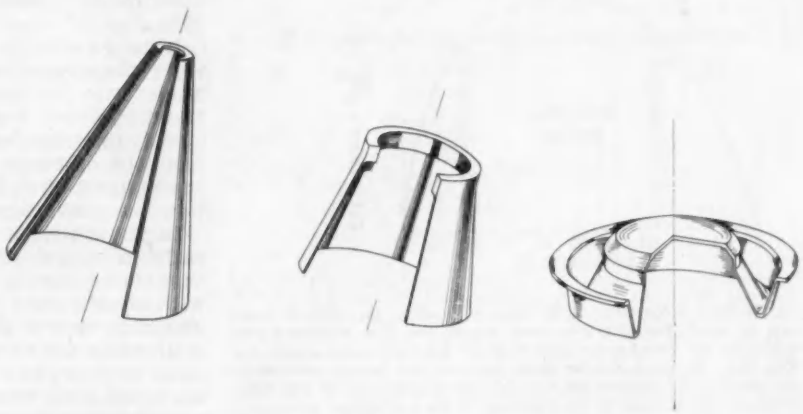


Fig. 2—Some configurations are best achieved by preforming and then "Floturning."

Fig. 3—Typical "Floturned" parts.



• Utility ratio
• Turbine counter head

2 Guides for Efficient

TWO of the major considerations in designing a torque converter are:

1. Utility ratio.
2. Turbine counter head.

Normally, the most important torque converter characteristic is the utility ratio. The utility ratio will be arbitrarily defined as the ratio of the speed ratios where the efficiency of power transmission is 70% or more. In other words, the utility ratio is equal to the highest speed ratio at which the efficiency curve crosses the 70% efficiency line divided by the lowest speed ratio at which the curve again crosses the 70% line (Fig. 1).

Converter performance tests have shown that the slope of the low-speed-ratio portion of the efficiency curve can be represented by a line drawn from the zero torque, zero-speed-ratio point of the performance curve to a speed-ratio point on the 100% efficiency line that is equal to the reciprocal of the stall-torque ratio.

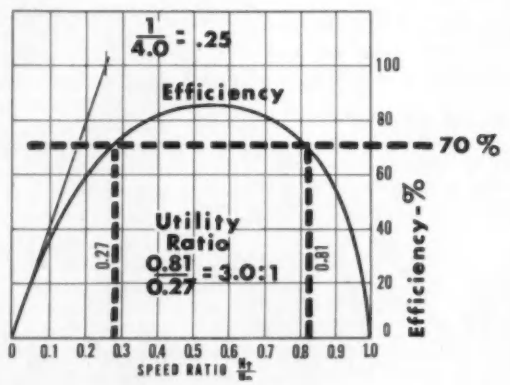


Fig. 1—Torque-converter utility ratio is equal to the highest speed ratio at which the efficiency curve crosses the 70% efficiency line divided by the lowest speed ratio at which the curve again crosses the 70% line. The slope of a line drawn from the zero torque, zero-speed-ratio point of the performance curve to a speed-ratio point on the 100% efficiency line is equal to the reciprocal of the stall-torque ratio.

For most industrial applications, be it shovels, tractors, or end loaders, there is a constantly changing load demand which causes the output speed to vary over a wide range from near stall to racing. The chief justification for any hydraulic torque converter is its ability to automatically adjust output torque to load demand variations without any conscious effort on the part of the operator. This ability can be fully realized only if the converter has a sufficiently broad operating range so that the number of transmission shifts behind the converter can be reduced to a minimum.

A measure of the usable output horsepower is represented by the area under the curve of output horsepower plotted versus output speed. This evaluation should, of course, be tempered by the time interval spent in each portion of the curve during the work cycle. Using this yardstick of overall usable power, peak converter efficiency could be second in importance to the total efficiency curve that rises above a predetermined efficiency level such as 70%.

In terms of vane shapes, this means that with the wide dispersion of the approach-velocity attack angles into the various converter stages, the design trend has been towards those shapes that will efficiently pass the flow at the widest possible variance from the optimum attack angle. This accounts for the bulbous or bluntly rounded vane noses encountered in converters of wide utility ratio.

In the constant struggle to obtain higher utility ratio, a major design consideration has become obvious as shown by Fig. 2. Assume a converter with an efficiency curve with a utility ratio of 2 to 1. The high end of the curve crosses 70% at 0.8 speed ratio while the lower end crosses at 0.4. If it is desired to improve the ratio to 3 to 1 mathematically, we could hold the low end at 0.4 speed ratio and attempt to develop blading with good high-speed-ratio-performance characteristics. The crossover

Based on paper by **J. B. Black and M. W. Dundore,** Twin Disc Clutch Co.

Torque Converter Design

point for the high end would have to move out to 1.2 speed ratio.

A second alternative would be to hold the high end at 0.8 speed ratio and use blading with good low-speed-ratio characteristics. We would then have to move the lower crossover point back to 0.267 speed ratio. It is readily apparent that a much smaller gain in low-speed-ratio performance will produce greater utility than a much larger increase in the high end. It is also apparent by the slope of the efficiency curve that the stall-torque ratio will increase considerably when the low-speed-ratio blading is used. Usually, converters with wide utility ratios have high stall-torque ratios.

Turbine Counter Head

Another major consideration in the design of any single stage converter is the position and size of the turbine stage relative to the impeller. A vane system rotating builds up a head which tends to propel the fluid outward due to the centrifugal forces acting on the fluid particles. This force depends entirely on the rotational speed. In converters of the inward-flow-turbine type, such as those shown in Fig. 3 (a, b, and c), although the flow is being forced through the turbine inwardly, the turbine as it picks up speed, builds up a counter centrifugal head which opposes this inward flow.

The maximum flow occurs when the turbine is stalled and it gradually decreases with increasing turbine speed until the turbine head equals the impeller head and the flow ceases. This decreased flow tends to reduce the torque absorption of the impeller. However, as the flow decreases (Fig. 4), so does the absolute velocity leaving the stator stage. This means that the impeller inlet whirl will decrease tending to increase the impeller torque. As this decreasing plus increasing tendency varies in net effect, the theoretical flat input curve is modified approximately as shown in Fig. 5. At the stall end, the curve can fall off (a), or actually rise (b). The actual characteristic will depend on the converter design.

Shortening the impeller vanes and changing the stator from basically axial to radially outflow as shown in Fig. 3(b) decreases the centrifugal head of the pump relative to the turbine counter head. The rotating mass of oil contributing to turbine counter head extends down to the center of the circuit and not just to the vane inner diameter. This causes the flow shut off to occur at a much lower speed ratio and results in a sudden drop in both input torque absorption and in output torque shortly after passing the clutch point or 1:1 torque ratio point. This rapid unloading of both the prime mover and the output shaft can be useful in certain applications

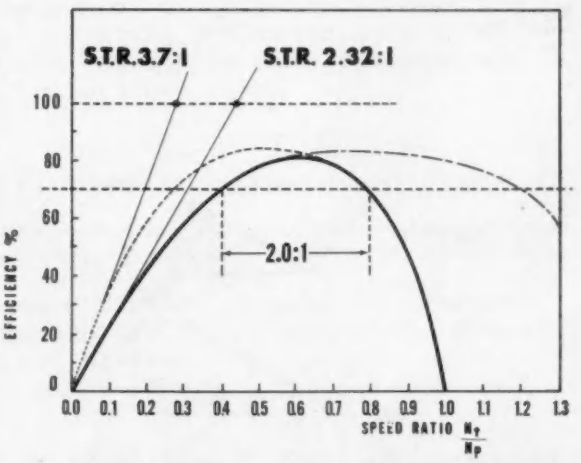


Fig. 2—Utility ratio can be increased by holdng the low-end speed ratio and moving out the high-end speed ratio or by holding the high-end speed ratio and improving low-speed ratio characteristics. It is apparent, however, that a small gain in low-speed-ratio performance will produce greater utility than a much larger increase in the high-end ratio. It is also apparent by the slope of the efficiency curve that stall-torque ratio increases considerably when low-speed-ratio blading is used.

where it is desired to limit the top speed under light load conditions without the use of an output shaft governor. In contrast to an output shaft governor, which has to sense an overspeeding condition and then reduce engine output by closing down the throttle, which takes some time, the sudden unloading of the output shaft which occurs based on speed ratio corrects the overspeeding as soon as it occurs by reducing the high torque causing the overspeeding.

Moving the stator to the other side of the circuit as shown in Fig. 3(c) reduces the turbine counter head by increasing the inner diameter of the rotating oil mass. At the same time, if the impeller vanes are lengthened, the centrifugal head effect of the impeller is increased. Thus, the angular velocity of the turbine must now exceed that of the impeller by some amount before shut off can occur. This increases the runout RPM and therefore the delivered horsepower at high speed ratios. The comparative characteristics of these two types is shown in Fig. 6.

(Paper, "Torque Converters Can Be Different," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

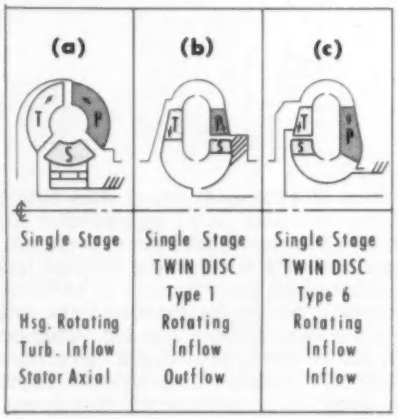


Fig. 3—In torque converters of the inward-flow-turbine type, although flow is being forced through the turbine inwardly, the turbine, as it picks up speed, builds up a counter centrifugal head which opposes this inward flow.

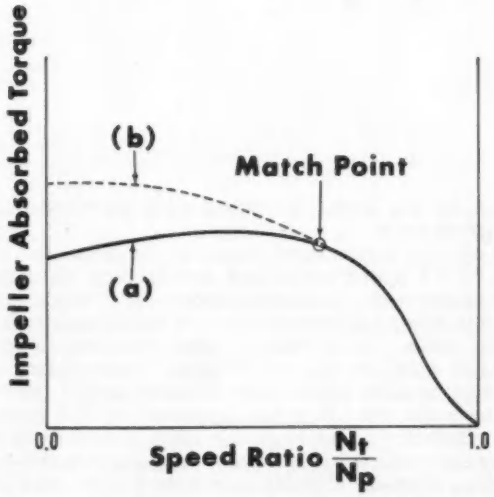


Fig. 5—Typical torque curve for the type of converter shown in Fig. 3-a. At the stall end, the curve can fall off (a), or rise (b) depending on the converter design.

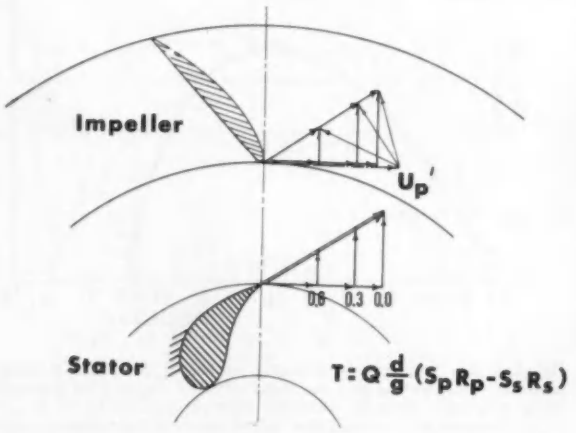


Fig. 4—As flow decreases, so does the absolute velocity leaving the stator stage. This means that the impeller inlet whirl will decrease tending to increase impeller torque.

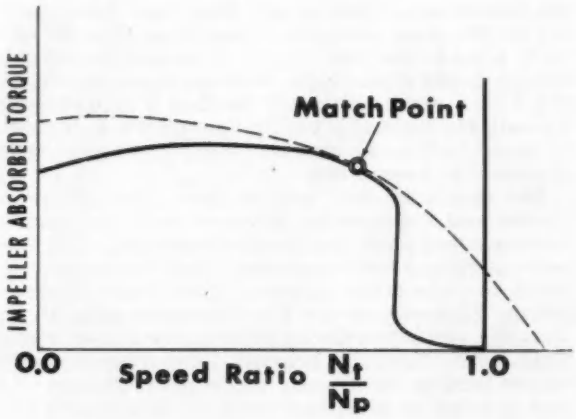


Fig. 6—Typical torque curves for the converter types pictured in Fig. 3 (b and c). The solid line is representative of the converter shown in Fig. 3-b.

SAE LOOKS OVERSEAS

by F. B. GREATREX, *Manager, Hucknall Aerodrome, Aero Engine Division, Rolls-Royce, Ltd., England*

COMET IV WILL HAVE EYELID REVERSER

When the Comet IV goes into service, it will have a Rolls-Royce thrust-reversing arrangement in which the main gas duct is provided with fixed reverser outlet ducts. Eyelid-type doors normally covering these are, for reversal, moved to open these ducts and close the main gas duct.

To go from the forward-thrust portion of the throttle quadrant rearward to the reverse-thrust portion, the pilot must pull back an "intent" lever, which opens the reverser outlet doors, then lift the throttle over a detent.

FORWARD-THRUST LOSSES ARE LOW; REVERSE THRUST IS 55%

The weight penalty incurred by fitting the thrust-reverser unit in place of standard jet pipe is 225 lb. The thrust loss under forward-thrust conditions is low, only about 1% at cruise. The gas duct is very clean aerodynamically with the reverser in the forward-thrust position. The eyelids cause a thrust loss of only about 1/4%. The seal leaks only 1/4% of the gas flow under takeoff conditions, even after a long period of operation.

Rolls-Royce has installed the reverser on a Hunter aircraft used as a flying test-bed and has carried out 186 landings. The reverser gives 55% reverse thrust, without attachment of the jet to the fuselage surface and without any inlet temperature rise.

by FRANCIS J. MARKEY, *Moraine Products Div., General Motors Corp.*

Mr. Markey has been in Australia as a consultant on brakes. He plans to visit in the Far East, Germany, and England before returning home.

AUSTRALIA USES SAE SPECS

SAE standards are widely used by Australian automotive manufacturers. Temperature requirements are sometimes waived or modified, however. It's seldom colder than 10 F, even on the mountain tops of Australia, and highest recorded temperatures are in the 90's.

Australia has about 2 1/2 million highway vehicles—or about one motor vehicle per 4.3 people. (Only the United States and Canada have higher vehicles per capita ratios.) There were 208,000 registrations of new vehicles in 1956. Holden cars and trucks—built by General Mo-

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. G. A. Rosen, chairman

SAE LOOKS OVERSEAS

tors-Holden's, Ltd.—accounted for about a third of all vehicles registered last year.

HOLDEN MAKES NEARLY 69,000 UNITS IN 1956

The Holden car has a 6-cyl engine of 132 cu in. displacement and is rated at 70 bhp. Wheelbase is 105 in; weight is 2300 lb. Body is integral with frame. Very few parts are imported. In fact, the Holden car is said to be "96% Australian content." Just as in the U.S., the station wagon is very popular. Holden station wagon capacity is sold out for almost two years.

by K. HAGERUP-SVENDSEN, *Scandinavian Airlines System, Inc.*

COMPUTER TO SOLVE ENGINEERING PROBLEMS

SCANDINAVIAN Airlines System expects to use an IBM 650 Magnetic-Drum Data-Processing Computer for solving engineering problems associated with production, aircraft, and flight planning. The computer will also be used to process mathematical calculations and technical, production, and operating statistics. Delivery is expected early next year.

Advance work being done in anticipation of the changeover to electronics includes:

PREPARING FOR CHANGEOVER TO ELECTRONICS

1. Plotting of present routines.
2. Analyzing information received and working out new aims.
3. Investigating the possibilities of coordinating information on different functions.
4. Working out possible schemes for handling IDP/EDP routines and discussing with the parties concerned for establishment of a final system and organization.
5. Translating the final scheme decided upon into type 650 language (codification into working plan).
6. Checking the working plan in the computer and making any necessary corrections.

COMPUTER ASSUMES RESPONSIBILITY

When the 650 computer is received and steps 1-6 above completed, the computer will assume responsibility for further work. The routines set up, as well as the machinery itself, will be checked and appraised continually with regard to general development. Any possible alterations to meet new demands will also be considered.

TRAINING PERSONNEL

To provide trained personnel, some general instruction courses on the computer have been given. The systems group has received complete instruction on the 650. Further training will be given through periodically repeated meetings. All training on the preparatory phases was completed early this year.

OTHER FUNCTIONS

Other functions which the computer is expected to assume include: stock, ticket, freight, salary, and wage accounting; bookkeeping, tariff calculations, seat reservations, and crew and traffic planning.

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C.G.A. Rosen, chairman

Automation and new processes offer . . .

New Opportunities for Cutting Foundry Costs

Based on secretary's report by **L. Wood,** Sand Supervisor, Chevrolet-Tonawanda Foundry, General Motors Corp.

Automation

SEVERAL factors are inherent in foundry operations that place automation in a favorable light. Many operations are repetitive and involve handling of heavy materials. Still others require job assignment in areas of heat, dust, and fumes. Automation also offers the potential for better and more consistent quality through the elimination of hand operations.

The initiation of an automation program in the foundry requires careful study to determine the area of greatest savings. Once a specific area has been selected, the general arrangement and layout should be determined. All departments concerned should be contacted, particularly the production supervision who will be responsible for the operation. The program should be coordinated by an engineer who is also responsible for design, specifications, development, construction, and installation. Safety and standardization of parts in the installation also demand consideration. The engineers responsibility continues until the program becomes a complete entity, and until the new operation is a satisfactory part of the overall operation.

The degree of automation depends on the volume of production desired, and on the versatility of available equipment. The capacity of allied equipment, either preceding or succeeding the automated operation, must also be considered. Other factors which influence the success of automation are proper scheduling of equipment and an effective maintenance program. The maintenance department will have to be re-educated as to the demands automatic equipment will place on it. With higher production and interlocking operations, down time will result in an entire production unit being down instead of one machine as in the past.

Specific areas offering potential savings through either an increased production rate or a decrease in manpower are automatic machine cycles, continuous core baking, and continuous casting cooling. Automatic shakeout, and mold and sand handling also fall in this category. Conveying of castings through automatic core knockout stations, continuous grinders, and shot blasting offer further savings. Advantages realized in the core room are the elimination or reduction of vents, wires, and rods, by virtue of the more uniform cores obtainable with core blowers. Surface finish is usually better and more uniform. High-capacity automatically-cycled machines offer further opportunities in automatic coping and venting operations.

Sand handling in both the core room and foundry lends itself well to automatic mixing cycles which contribute to more uniform sands. Distribution of core and molding sands by pneumatic systems means less dust and labor involved. Working conditions are improved, as is the break-in time for personnel, when the skilled molder or core maker is replaced by the machine operator.

New Processes

The foundry industry of today is offered a variety of new processes which allow it to reclaim materials formerly discarded, to reduce the amount of materials required, obtain better finishes, and maintain closer tolerances. Castings can now be made that were considered uncastable or difficult to cast economically, and this can be accomplished with a reduction in cost. These new processes include sand reclamation, shell and CO_2 coremaking and molding, and the hot-blast cupola.

Sand reclamation enables today's foundryman to

recover, economically, discarded sand with physical properties that are compatible with core and molding sand requirements. Wet reclamation is composed of three essential operations, in addition to preliminary screening and magnetic separation. Scrubbing of the sand grains removes additives, washes, and core and mold binders. Classification serves the dual purpose of removing the material loosened by the scrubbers and of classifying the sand by grain distribution, which also removes the undesirable fines. Dewatering is accomplished by filtering, followed by conventional drying procedures.

Reclaimed sand possesses definite characteristics that distinguish it from new sand. The sand grains have a retained clay, ignition loss, and free iron under 1%. The grain distribution can be controlled within ±2 AFS numbers of the base sand. Grain shape is altered from subangular to a more rounded shape, although the grains are not in the rounded classification. This results in greater permeability, as compared to the new sand.

Use in the foundry results in equal green strengths and reclaim sand is used interchangeably with new sand. Core room strengths are somewhat lower and, in some cases, a slight increase in binder is necessary. The percent of additional binder, however, is not a linear relationship to the amount of reclaim present in a mix. In all cases a cheaper mix results due to the much lower cost of reclaim.

Reclaim sand contains a large amount of gas compared with new sand. However, this gas apparently evolves at the lower temperatures, and at such a rate that it is completely dissipated before the mold cavity is filled and the iron solidified. No difficulty has been experienced with this gas and reclaim is used almost interchangeably with new sand in the core room.

The wetability of reclaim does not compare with that of new sand and a wetting agent is used in core mixes to obtain a homogeneous mix. Reclaim is gray in color which renders the color test for green cores valueless. This coloration is probably due to material remaining in the crevices of each sand grain.

Reclaim is a new material possessing definite characteristics that requires special provisions in some cases, to utilize it efficiently. One reporting foundry is using 70% reclaimed sand at a cost approximately 20% that of new sand, which has resulted in substantial savings.

Shell molding offers savings in sand and produces castings with better finishes and closer tolerances. Shell molds and cores also make possible the casting of intricate parts which are not practicable in green sand. Shell molding offers competition with die castings in applications where wearing qualities are desired.

The trend in shell molding is to the use of coated sands. Coated sands result in resin savings, less dust, and a reduction in cycle times. They may be conveyed pneumatically without segregation while mechanical mixtures must be handled by screw conveyors and other conventional sand-handling equipment.

The problem of cracking and distortion of shell molds during solidification can be solved by a number of different methods. One solution is to form shell bosses on the back of the drag shell. These bosses must be rubbed or ground even, to provide uniform support. Another unique method is controlled cracking. By notching the shells, cracks are controlled and directed into noncritical areas such as runners or risers. Ribbing the shell to impart rigidity is possible in certain cases. The conventional methods of bolting, gluing, and the use of clips may also be used to control deflection and distortion.

Curing of the shell and the production of a shell of uniform section thickness are best accomplished by maintaining uniform temperatures across the pattern surface. Pattern projections or bosses, which are usually furthest removed from the heat source and present problems in maintaining temperature, may take advantage of small heating units placed in the affected area. Temperature and curing times should be controlled to produce the correct shell thickness for each job so that cracking and distortion may be reduced.

Specific examples of jobs converted to shell casting include the governor body and bushing for the hydramatic transmission. These parts were formerly die cast of aluminum, but when used in conjunction with steel piston rings excessive wear resulted. The intricate coring involved precluded conventional casting methods. Upon conversion to shell casting, which allowed the use of a ferrous metal, wear in the ring grooves was practically eliminated. These two parts are cast with only 1/32 in. machining allowance. Grooves cast by the core require almost perfect alignment with the cope and would be difficult to cast in green sand.

CO_2 bonded cores and molds is the newest of the processes currently gaining favor among foundrymen. This process offers good dimensional stability due to the sand being hardened in contact with the core box or pattern surface.

The CO_2 process is based on the chemical reaction between the sodium silicate coated sand grains and CO_2 gas. As the gas is passed through the core or mold under pressure, the silicate converts to a silica gel which binds the sand. The sodium converts to sodium carbonate.

Standard core mixers are used to mix the sand, liquid sodium silicate, and any additives used to control collapsibility. Any bentonite free sand may be used, although in making molds where the pattern is drawn before gassing, some foundries use ball clays to obtain green strength at a sacrifice in hardness. Additives in common use include seacoal, pitch, and various sugars. Percentages of binders and additives are determined by grain size and shape.

Gassing of the cores and molds is accomplished by probing or manifolds. Probing is most effective in large chunk cores, while manifolds work well with smaller cores or cores of smaller sections. Cores of uneven sections may be gassed by using a manifold after running a vent rod into the thicker sections. This allows the gas to reach the thicker sections quickly and provides even gassing. Each type of core, however, presents a special problem and requires experimentation to work out the most efficient gassing procedure.

Finish is reported good where the core is not overgassed, resulting in friable edges. Finish is also impaired when the core is scuffed in handling and

the surface skin disturbed. CO_2 cores possess little tensile strength, and if testing is carried out to evaluate binders, compression tests must be used.

Advantages of the CO_2 process include immediate use of cores, as gassing time is usually less than a minute. No dryers or core ovens are required, and elimination or reduction in rods and wires, with a core free from distortion and sag are effected. Unskilled labor can be used due to the simplicity of the process. Initial cost of equipment is negligible. Casting scrap from blows can be forgotten in most cases, due to absence of gas in cores or molds, eliminating the need for venting.

Disadvantages include low bench life of sand mixes, collapsibility problems with gray iron, and difficulty in obtaining fine detail unless core equipment is perfect.

Hot-blast cupolas present the opportunity for foundries to greatly reduce melting costs. Two different procedures, the externally-fired type and the recuperative type, have been developed to make this possible.

The externally-fired type heats the incoming blast air to wind box temperatures ranging from 400 F to 750 F. This type of preheating requires fuel to fire the heat exchanger at costs varying from 14¢ to 20¢ per ton of metal charged. The advantage of the externally-fired heat exchanger is that the initial equipment and installation is usually not as expensive as the recuperator type.

The recuperator type of hot blast cupola captures some of the wasted heat energy that normally is allowed to escape out of the top of the stack. The hot exhaust gases are passed through a heat exchanger heating the incoming blast air necessary to support the combustion used to melt the iron.

A No. 12 cupola emits approximately 50,000,000 Btu of heat energy per hour, and it is this heat that is recaptured. This is accomplished by capping the cupola and by passing the exhaust gases through the heat exchanger counter flow to the incoming blast air. Temperatures to 950 F have been obtained with this type of system.

The desired wind box temperatures varies with the foundry and is dependent upon the type of iron produced, the required chemical specifications, the desired pouring temperatures, and the amount of iron melted. The main advantage of the hot-blast cupola is the considerable savings in coke. Iron coke ratios are increased from 8 to 1 using cold blast to 12 to 1 using the hot-blast system.

Other savings that result from the reduction in coke and from the increase in wind box temperatures are a decrease in the oxidation loss of silicon and manganese. The melting rate can be increased because of less coke usage. This decrease of coke requirements also allows a decrease in wind box velocity and back pressure, both very desirable from the operations standpoint.

Cupolas have become a nuisance in residential areas, as well as some industrial sites because of the high degree of air pollution they can cause. Effective control of emission from cupolas is difficult because of the large volume of gas involved, of high temperatures of these gases, and of the great number of ultra-fine fume particles in the gas. Fly ash emission averages from 15 to 30 lb per ton of metal charged. A dry-type dust collector used in conjunction with the recuperator-type hot-blast system eliminates fly ash and other foreign material from the exhaust gases.

The exhaust gases first pass through the heat exchanger, giving up some of their heat to the incoming blast air. They are then introduced at high velocity into the small end of a large cone which is enclosed in a circular structure. When the gases and entrained fly ash reach the lower edge of the cone, the velocity has decreased, allowing the fly ash to settle out and to be collected. The exhaust gases are then allowed to flow up around the outside of the cone and to be discharged into the atmosphere relatively free of foreign material. This type of collector overcomes the corrosion problems inherent in the water spray types.

The installation of either type of hot blast system in conjunction with the proper dust control equipment is an important factor in the foundry cost picture today.

(The report on which this article is based, together with six other production panel reports, is available as SP-318 from SAE Special Publications, 485 Lexington Avenue, New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

SERVING on the panel which discussed "Modern Foundry Practice" were:

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Production Superintendent
Chevrolet-Tonawanda Foundry
General Motors Corp.

L. Wood, panel secretary
Sand Supervisor
Chevrolet-Tonawanda Foundry
General Motors Corp.

A. M. Clark
Manager, Manufacturing Engineering
Foundry Operations, Ford Motor Co.

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Armour Research Foundation

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Central Foundry Division
General Motors Corp.

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General Motors Corp.

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Plant Engineer
Pontiac Foundry Division
General Motors Corp.

Phosphorus Fuel Additives

Spark-plug fouling

in passenger cars

. . . has been investigated and discussed for many years. Today's low-speed city driving and engine-design trends (larger engines, higher compression ratios, and better volumetric efficiencies) are clearly aggravating the problem. That's why these authors decided to make a survey of the situation and study possible ways of doing something about it.

Their survey of fouling in 193 late-model passenger cars of four popular makes showed that approximately one-third of the spark plug sets were fouled sufficiently to cause at least a 20% decrease in vehicle performance. While the vehicle models and number of cars involved are limited and do not completely represent the car population nor types of service, the survey did provide a sample of the three main price classes of cars. The results indicate that a considerable amount of spark-plug fouling exists in vehicles driven in city and city-suburban service. Recognition of spark-plug fouling by car owners varied with car make.

The authors studied the effects of changes in antiknock compound, fuel-sulfur concentration, and changes in fuel-base stock composition. They note, however, that the commercial formulation of a finished fuel is dictated primarily not by spark-plug fouling but by other considerations, such as fuel octane number. They feel, nevertheless, that the large effects of changes in composition of the fuel base stock indicate an important area for future research.

They also found that phosphorous additives at least double the time to plug failure, and thus seem to offer a commercial solution to the problem.

Given here is the discussion of the effects of changes in base-stock composition and of phosphorus additives.

RECENT tests show that the fouling tendencies of spark plugs can be alleviated by such means as:

- Changes in the composition of the fuel base stock.
- Use of phosphorus fuel additives.

Effects of Fuel Hydrocarbon Composition

During the last few years, automotive-engine designs have created a demand for fuels of progressively higher octane number. Anticipating that this trend would continue, studies were made by Ethyl's refinery technology group of three posible refinery approaches that might be employed for future production of automotive gasolines.

Three 100-octane fuels, representative of the products of these refinery approaches, were blended in quantity, and a test program was conducted to study their operating characteristics in engines. Analyses of the three fuels are shown in Table 1. Their similarity with respect to sulfur content and 90% distillation point would indicate that their deposit-forming tendencies would be directly dependent on their hydrocarbon type and composition.

Each fuel was tested in three cars of each of three different makes and in one engine on a dynamometer, following standard road and dynamometer laboratory test procedures. Consistent with operation in actual owner service, established carburetor settings were not changed between fuels, although the specific gravity of the fuels did vary. The test results are presented in Fig. 1, and show a greater than 2-to-1 difference in the plug-fouling tendencies of these fuels in vehicle operation. Fig. 1 is based on miles or hours to fouling expressed as percent relative, with 100% representing the fuel-vehicle make combination with the shortest mileage to fouling.

Agreement in the relative ratings of fuels was good among cars of a given make and among the three different makes used. The dynamometer tests also showed a definitely superior performance for fuel 3.

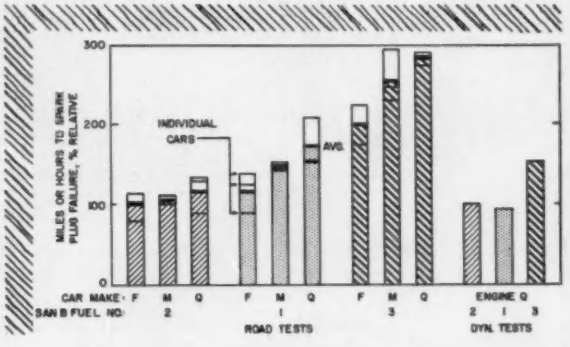
The test results demonstrated that base-fuel composition materially affects spark-plug performance, and stimulated interest in further study of the relationship between fuel composition and spark-plug fouling. Differences in the fouling tendencies of these three fuels were attributed to hydrocarbon composition. Attempts to link hydrocarbon type with fouling, based on these test results, indicated an apparent relationship between the saturate content of a fuel and spark-plug performance, since

Reduce Spark-Plug Fouling

Based on paper by **C. A. Hall, R. C. Beaubier, E. C. Marckwardt, and R. L. Courtney,** Ethyl Corp.

fouling increased directly with saturate content.

To further explore this relationship, six additional dynamometer tests were conducted using base fuels selected to cover a wide range of saturate content. These tests failed to show any apparent connection between spark-plug fouling and saturate content or any of the other whole or fractional fuel components. They were, however, of value in making more obvious the complexity of the relationship between fuel composition and spark-plug fouling. Other factors such as the interrelationship of hydrocarbon types and differences in members of a particular hydrocarbon family must be investigated for an understanding of fuel-composition effects. Work is continuing toward this end at the present time. The large differences in spark-plug performance shown in these tests would indicate that the study of fuel composition represents a profitable field for future research.


300
200
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MILES OR HOURS TO SPARK PLUG FAILURE, % RELATIVE
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CAR MAKE · F M Q F M Q F M Q ENGINE Q
SAN B FUEL NO: 2 1 3 2 1 3
ROAD TESTS
DYN. TESTS

Fig. 1—Effect of three base fuels on spark-plug fouling.

Phosphorus Fuel Additives

Phosphorus is the active component of certain additives used quite widely in commercial gasolines to inhibit spark-plug fouling and surface ignition. The effectiveness of phosphorus is attributed to the formation of high-melting, lead-phosphorus deposits on the spark plug insulator.

In the laboratory, numerous phosphorous compounds have been tested in vehicle and dynamometer engines. Most of this testing, which has been conducted under strict laboratory control, was designed to detect fouling in its incipient stage, before its effects are evident to the average driver. To evaluate phosphorus in terms more practical and significant to an automobile owner, another test approach was used. This consisted of evaluating phosphorus by the effect of fouling on the accelerating ability of a vehicle, since surveys have shown that sluggish acceleration and attendant engine roughness, if sufficiently severe, are recognizable by an average driver.

Each of two phosphorus additives—one commercial and the other experimental—was tested at a 0.2 theory concentration level in eight cars representing four different vehicle makes. Fuel 2-E, which contained 3.0 ml tel/gal as motor mix, was used as the base fuel, and a reference baseline test of this fuel was run in each car. All tests were concluded either after spark plugs became sufficiently fouled to cause a 20% increase in acceleration time as compared to new spark plugs or, in the case of additive tests,

Table 1—Fuel Inspection Data

	Fuel		
	No. 1	No. 2	No. 3
Hydrocarbon Type:			
% olefins	28.5	12.0	9.2
% aromatics	18.4	29.7	47.6
% saturates	53.1	58.3	43.2
gravity, API	61.9	58.8	52.1
ASTM Distillation Temperature, F:			
10%	133	130	133
50%	220	222	231
90%	345	342	345
sulfur, %	0.028	0.026	0.023
research octane No. (3ml tel/gal)	99.9	99.3	99
motor octane No. (3ml tel/gal)	88.9	90.4	88.1
Composition, %:			
Alkylate	22.5	22.5	—
Catalytically cracked	68.0	52.5	40
Polymer	9.5	—	—
Straight-run 200 F ep	—	—	25
Severe cat. reformate	—	25.0	—
Extracted aromatics	—	—	35

after mileage approached 15,000 without meeting this failure criterion.

The test results, which are presented in Fig. 2, show that, without exception, phosphorus substantially improved spark-plug performance, although the response to phosphorus varied with the different vehicle makes. The minimum increase in the mileage to spark plug failure was 82% in car D-7; the maximum increase exceeded 300%, and was obtained in car M-4. The eight-car average increase due to phosphorus was greater than 150%; some cars operated on phosphorus had not reached the fouling criterion when the tests were voluntarily ended.

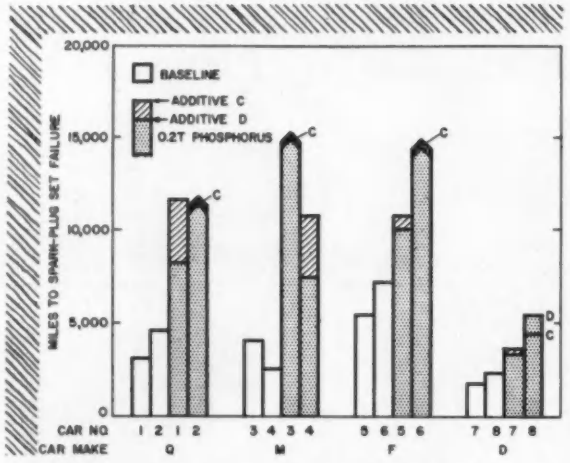


Fig. 2—Effect of two phosphorus additives on miles to spark-plug fouling.

Additive C improved spark-plug performance by more than 100% in seven of the eight cars tested; with additive D, mileage increases exceeded 100% in six of the eight cars. In four of the five vehicles which met the fouling criterion with phosphorus additives, additive C was superior to additive D. These data, which illustrate that differences exist among phosphorus compounds, have been substantiated by dynamometer tests.

The road-test data presented here are considered of particular significance in that they reflect the effects of phosphorus under conditions, and in terms, more practical to a car owner than those of the usual laboratory tests.

(Paper, "Spark-Plug Fouling: A Survey—Test Procedures—Fuel Factors," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Vapor Lock . . .

. . . yields to new method. Fuel vapor-locking tendencies can now be measured more accurately by means of modified version of Reid vapor-pressure technique.

Based on paper by **John D. Caplan and Charles J. Brady,** General Motors Corp.

A PRACTICAL method of measuring the vapor-locking tendencies of gasoline has been developed. It is designed to replace the long used Reid vapor-pressure technique, which has been considered unsatisfactory by many engineers for some time.

Briefly, the new technique uses a modification of the Reid vapor-pressure apparatus, so that the vapor/liquid ratio is 25/1 instead of the conventional 4/1. This ratio has been found to give results that correlate quite closely with the vapor-handling capacity of car fuel systems.

A change in the bath temeprature from 100 F to 140–150 F was also contemplated, as this is more nearly comparable to actual operating temperature. Both experimental and theoretical studies showed that this was not necessary. Since increasing the bath temperature makes it more difficult to manipulate the Reid bomb, the 100 F bath temperature has been continued.

The new method numbers among its advantages:

1. It provides a single number which realistically predicts the vapor-locking tendencies of gasolines. This number is easily and rapidly determined.
2. It more realistically evaluates the effects of small weathering losses on vapor-locking tendency than does Rvp.
3. It allows direct intercomparisons of vapor-lock test results to be made when using different reference fuel systems.
4. It makes it possible to establish distribution curves of volatility requirements of the car population for vapor-lock-free operation and of the vapor-locking tendencies of gasolines marketed.
5. It permits comprehension of the vapor-locking tendencies of both passenger cars and gasolines by both petroleum technologists and automotive engineers.

Why 25/1 V/L Ratio Was Chosen

The 25/1 *V/L* ratio was chosen for the following reasons:

1. A ratio anywhere in the range between 20 and 30 will provide a satisfactory prediction of vapor-lock performance, which will be a radical improvement over the use of Rvp.
2. Of the four cars tested, the best correlation was obtained for two of the cars in the range between 20 and 25 and for one of the cars in the range between 25 and 30. For the fourth car, sufficient

data over a narrow temperature range were not obtained to indicate which specific ratio between 20 and 30 would give the best correlation.

3. It is expected that the vapor-handling capacity of car fuel systems is more likely to increase than decrease. Consequently, a ratio of 25/1 provides a suitable compromise between immediate and future applications. In this connection, it should be noted that present-day cars will still be in operation 10–15 years from now.

4. Radical changes in fuel systems which result in marked increases in vapor-handling capacity will require an upward change in the ratio and a re-evaluation to determine the ratio of best compromise. The possibility of such changes is inherent in any bench test which is designed to predict the performance of a product in a mechanism such as a passenger car, which is continually being improved.

The modified bomb with a vapor/liquid ratio of 25/1 is now in use within General Motors for characterizing gasoline volatility. This vapor pressure is designated "General Motor Vapor Pressure (GMVP)."

(Paper, "Vapor-Locking Tendencies of Fuels—a Practical Approach," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Training Technicians . . .

. . . for automated machinery requires careful selection of applicants and a thoroughly-planned education program.

Based on secretary's report by **J. F. Morris,** Eastman Kodak Co.

HIGHLY trained technicians are needed for the building, testing, installation, and troubleshooting of automatic machines. Applicants will have to be carefully selected and educated to meet the specific needs of industry.

The current shortage of trained technicians presents a critical problem for both the manufacturer and user of automated machinery. Machine tools are increasing in complexity requiring technicians that combine skills of mechanical, electrical, and hydraulic functions. Men with these qualifications are available from few, if any, schools and therefore must be trained by industry to meet industry's specific needs.

Selecting people for technician's training involves considerable research into the backgrounds of the applicants. They need not only the mechanical and electrical aptitudes but should also like to work with their hands. They should be willing to make technician's work a career, not a training ground for future steps into other areas. To gain this attitude in an applicant, it is necessary to offer substantial wages, ever-increasingly interesting work, and an acceptable job title.

Specifically, the applicant for this type of training should be a high school graduate who has specialized in industrial arts and machine shop practice, with a good background in mathematics and physics.

Company training should be geared to the work ahead, giving the trainee the necessary shop and classroom work and a general background in the company's products and procedures. It should also include work on the latest types of machine tools with the trainee doing active production work.

Following this basic training, the technician trainee should work on shop assembly and testing of machine tools and electrohydraulic equipment. He should also be permitted to accompany the engineer and actually assist in field service work. As time goes on, additional training can be given in such fields as materials handling, quality control, methods engineering, and work standards, if so desired.

Such a program, based on careful selection and thorough specific training of applicants, should reap rich rewards in the form of highly-trained technicians who know what they're doing on automated equipment.

(The report on which this article is based, together with six other production panel reports, is available as SP-318 from SAE Special Publications, 485 Lexington Avenue, New York 17, N.Y. Price: $1.50 to members; $3.00 to nonmembers.)

SERVING on the panel "Training of Technicians for Maintaining Automated Machinery" were:

S. P. Bartles, panel leader
Eastman Kodak Co.

J. F. Morris, panel secretary
Eastman Kodak Co.

W. J. Moore
U. S. Department of Labor

D. T. Brown
Chrysler Corp.

T. G. Cober
International Business Machines Corp.

Carl Stugard
Cincinnati Milling Machine Co.

Graphic Illustrations Speak a Common Language

Based on paper by **Frederick Jantz,** Oldsmobile Division, General Motors Corp.

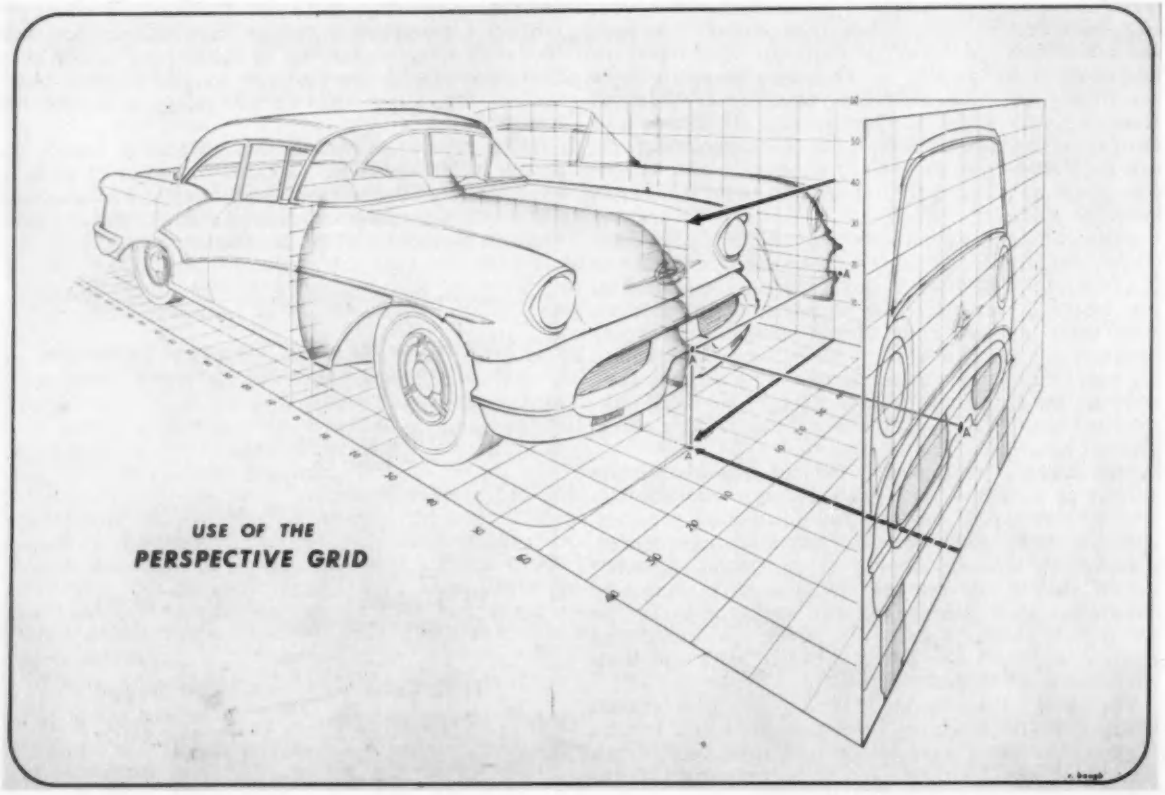
THE outstanding reason for the use of graphic illustrations is the ease and speed with which they can be read and understood. These perspective engineering drawings are coming into ever wider use as actual production drawings, usually supplanting the orthographic type of drawing.

Although drawn for production purposes, these drawings can, and do, make a much wider contribution. They can be used to:

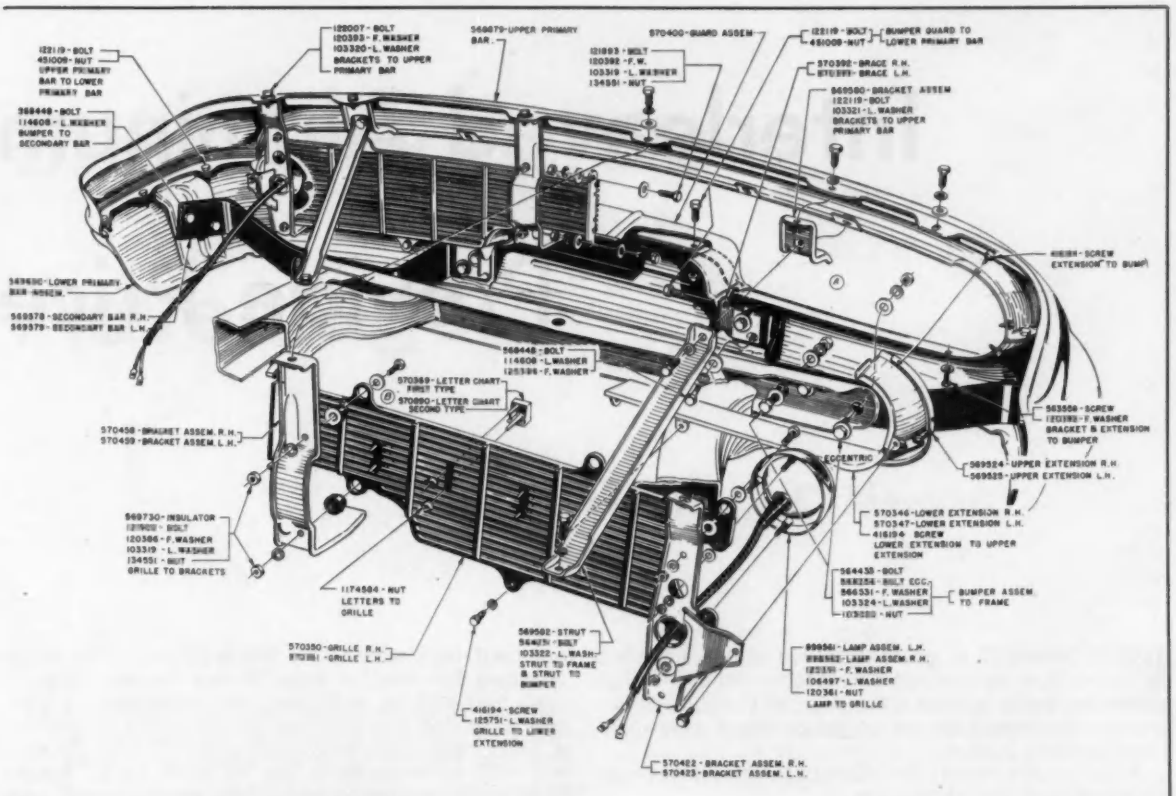
1. Give management a clear understanding so that quick decisions can be made.
2. Aid the process engineer and tool designer to visualize requirements for tooling and assembly scheduling.
3. Provide ready information for quality control and inspection departments.
4. Reduce shop errors caused by misinterpretation of blueprints. This is especially valuable when help is unskilled.
5. Provide uniform information for service, sales, and maintenance departments by using identical drawings in all manuals.

No matter what the language spoken—shop, engineering, sales, or service—a perspective drawing replaces thousands of words with the visual language of common understanding.

(Paper, "Development and Use of Graphic Illustrations in Product Engineering," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



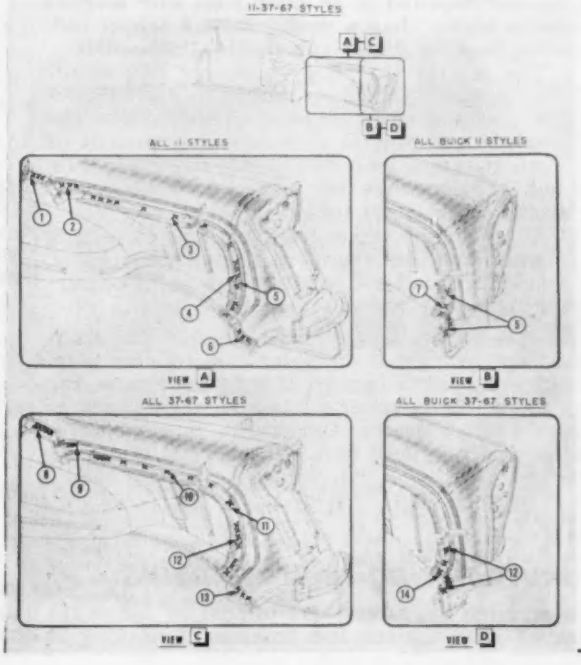
USE OF THE
PERSPECTIVE GRID


122007 - BOLT
120393 - F. WASHER
103320 - L. WASHER
BRACKETS TO UPPER PRIMARY BAR
122119 - BOLT
451008 - NUT
UPPER PRIMARY BAR TO LOWER PRIMARY BAR
568446 - BOLT
114608 - L. WASHER
BUMPER TO SECONDARY BAR
569679 - UPPER PRIMARY BAR
570400 - GUARD ASSEM.
121893 - BOLT
120392 - F.W.
103319 - L. WASHER
134551 - NUT
122119 - BOLT
451008 - NUT
BUMPER GUARD TO LOWER PRIMARY BAR
570392 - BRACE R.H.
570393 - BRACE L.H.
569580 - BRACKET ASSEM.
122119 - BOLT
103321 - L. WASHER
BRACKETS TO UPPER PRIMARY BAR
569680 - LOWER PRIMARY BAR ASSEM.
569578 - SECONDARY BAR R.H.
569579 - SECONDARY BAR L.H.
568448 - BOLT
114608 - L. WASHER
125396 - F. WASHER
570369 - LETTER CHART FIRST TYPE
570890 - LETTER CHART SECOND TYPE
570458 - BRACKET ASSEM. R.H.
570459 - BRACKET ASSEM. L.H.
569730 - INSULATOR
120386 - F. WASHER
103319 - L. WASHER
134551 - NUT
GRILLE TO BRACKETS
1174584 - NUT
LETTERS TO GRILLE
570350 - GRILLE R.H.
570351 - GRILLE L.H.
569582 - STRUT
564475 - BOLT
103322 - L. WASH.
STRUT TO FRAME & STRUT TO BUMPER
416194 - SCREW
125751 - L. WASHER
GRILLE TO LOWER EXTENSION
570422 - BRACKET ASSEM. R.H.
570423 - BRACKET ASSEM. L.H.
416184 - SCREW
EXTENSION TO BUMP
563508 - SCREW
120393 - F. WASHER
BRACKET & EXTENSION TO BUMPER
ECCENTRIC
569524 - UPPER EXTENSION R.H.
569525 - UPPER EXTENSION L.H.
570346 - LOWER EXTENSION R.H.
570347 - LOWER EXTENSION L.H.
416194 - SCREW
LOWER EXTENSION TO UPPER EXTENSION
564435 - BOLT
568256 - BOLT ECC.
566531 - F. WASHER
103324 - L. WASHER
103220 - NUT
BUMPER ASSEM. TO FRAME
569561 - LAMP ASSEM. L.H.
569562 - LAMP ASSEM. R.H.
122311 - F. WASHER
106497 - L. WASHER
120361 - NUT
LAMP TO GRILLE

Above:

This perspective engineering drawing of a front bumper assembly gives all the information normally found on an orthographic drawing, but it shows it more clearly and leaves little for the imagination to misinterpret. The shape of the part is immediately evident, the assembly sequence is clear, and the part and subassembly numbers are seen plainly.

A perspective drawing is much less bulky, also less expensive than an orthographic drawing. A drawing may present an entire assembly on a single sheet or on multiple sheets, each sheet representing a unit or a part of the installation complete in itself, drawn to a size not larger than 2×3 ft. If necessary to change a detail, only one sheet of a small portion of the entire installation is affected. This saves time and money in the handling of blueprints.



Right:

A good perspective drawing can be made to serve many purposes. Multiple sheet drawings can be reduced to book page size for inclusion in manuals. Here we have a typical sheet of graphic illustrations from a welding and assembly instruction manual.

Interleaved Aluminum Provide Price

DEVELOPMENT of an interleaved aluminum strip conductor has helped automotive electric-equipment designers to take advantage of the long-existing gap between base per pound prices of aluminum and copper.

Prior to this recent development, these disadvantages existed for aluminum:

- **The finished cost of aluminum magnet wire does not compare as favorably with copper magnet wire as do the base prices.**
  Reduced manufacturing and inventory costs inherent in the interleaved strip conductor help to reduce this disadvantage.
- **Volume required in an aluminum wire magnet coil is higher than a similar wound copper coil, often making direct substitution impossible.**
  The interleaved strip conductor coil eliminates the void spaces typical in a cross-section of a magnet wire wound coil so that the coil can be wound into the same amount of space as magnet coils made from copper wire.
- **Joining techniques for aluminum remained unsolved or too costly for many years.**
  Effective and economical methods of joining aluminum now available include coldwelding, shielded inert arc welding, and high-temperature soldering.

These recent offsets to long-existing disadvantages have resulted in consideration of aluminum for many new applications. Already the interleaved strip conductor is being applied to such items as field coils for generators and motors, starter coil relays, voltage regulator and ignition coils, and horn coils.

Manufacturing Improvements

To examine the advantages offered by use of interleaved strip, assume the problem of winding 20 one-half-inch wire coils. While 20 pay-off reels are required for magnet wire, it can be seen (Fig. 1) that two will be sufficient for interleaved strip—one each for the foil and interleaving insulation. A 10-in. wide roll with individual slitters for each coil will accommodate the 20 coils being wound. This leads to additional savings over those of conductor cost.

1. Reduced floor space required.
2. Reduced magnet wire reels in inventory.
3. Reduced conductor inventory—one gage of foil, if used in several widths, represents several wire gages.
4. Lower rejection rates and additional cost savings due to the simpler insulation system.
5. Simpler and less costly winding equipment.

ISWC Advantages

Design advantages of using the interleaved strip-wound coil are also indicated in Fig. 1. They include:

- **Space factors of 80 to 90% are obtained and although 60% more conductor volume is required, the coil can be wound into the space required for magnet copper wire coils.**
- **Since there is only one turn per layer, the layer to layer voltages are reduced. In a random wound magnet wire coil, the layer to layer voltage may be 10 to 20 times the turn voltage. Sometimes this high layer voltage requires the use of layer insulation, further decreasing the space factor and increasing material and winding costs.**
- **Interleaved strip conductor coils are easy to wind. High-speed equipment can be utilized.**

Strip Conductors Advantages

Based on paper by **T. E. Lewis and J. C. Meekins,** Reynolds Metals Co.

- **Better heat-transfer characteristics. Hot spots in the coils are virtually eliminated and lower average operating temperatures are obtained.**
- **Impregnation of the coil is unnecessary and can be eliminated to reduce costs.**
- **Advantage can be taken of the low base price of aluminum with significant cost reductions.**

New Joining Techniques

Recent developments have demonstrated that very effective and economical methods of joining aluminum are new available. Some of the more interesting of these which have proven practical are:

Coldwelding—Pressure welding at room temperature has become very useful in making aluminum joints. Joints formed by this method give high conductivity and high strength and are unaffected by life or temperature cycling.

Shielded Inert Arc Welding—This method is well known and is very useful in making many aluminum joints.

High-Temperature Solder—A new development in soldering makes use of the abrasive properties of a fiber glass brush. No corrosive flux is necessary as the brush effectively pretins the surface.

Automotive Applications

With continued use of aluminum, other applications are being considered. Voltage regulator and ignition coils can be wound with interleaved strip conductor. Lamp bulb bases and solenoid contact surfaces appear to be excellent applications, and a whole new opportunity is visualized in the field of wiring harnesses.

(Paper, "The Effective Utilization of Aluminum in Automotive Electrical Systems" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

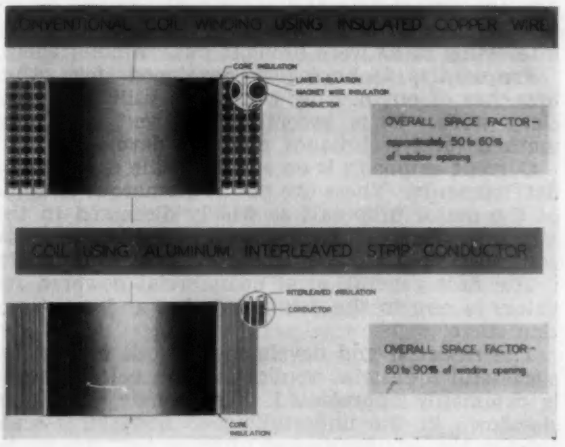
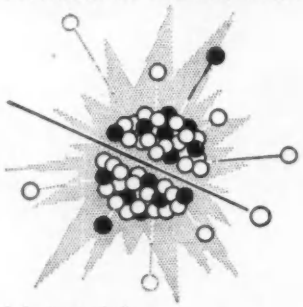


Fig. 1—Aluminum interleaved strip conductor can be wound in the same space as a copper wire coil. In addition, layer voltages are lower, heat-transfer characteristics are better, and aluminum base prices are lower than those of copper.

NUCLEAR NEWS NOTES



A feature of the
SAE NUCLEAR ENERGY ADVISORY COMMITTEE

Nuclear Field Gets

- *"Burnup" now in 3000-5000 megawatt-days per ton of fuel element range . . .*
- *NAM proposes nuclear power policies . . .*
- *Nuclear Congress Proceedings published . . .*

Reported by **Dr. Clayton R. Lewis,** chairman,
SAE Nuclear Energy Advisory Committee

THE nuclear field is retreating from glittering generalities and getting down to tough engineering details. This trend was evident at the recent American Nuclear Society meeting in Pittsburgh. Many interesting ideas were brought out. Among them:

Frequently, technologies developed for other branches of engineering cannot be utilized in nuclear work. It is becoming apparent that new methods and techniques must be developed.

Current emphasis is on smaller-scale engineering developments. These are not as glamorous as some of the major proposals so widely discussed in the last few years. But they are vitally necessary to continued progress toward economic nuclear power.

The first generation of commercial powered reactors is now in the detailed design and construction stage.

The research and development work needed for successful industrial application of nuclear energy is commonly appreciated. There may well be a slowdown in the undertaking of new, large-scale reactor projects until some of these auxiliary problems have been solved, many think.

There is a tendency, too, for companies having major nuclear commitments to increase their research and development efforts. Others, not fully committed to a large-scale effort in nuclear energy, are giving serious consideration to their position. In some cases, they are deciding to defer major commitments until technology problems have been better defined.

Atomic Energy Commission scientists announced study of a new reactor concept at Los Alamos in which the fuel is a molten plutonium alloy. This reactor is particularly well suited to small- and medium-sized installations. It shows considerable promise of producing cheap power in plants having 10,000-50,000-kw output. But a large research and development program must precede even consideration of constructing a prototype.

Fuel Costs

One limitation controlling costs in the fuel cycle for nuclear electric power has been the amount of "burnup" obtainable without reprocessing the fuel elements to remove fission product poisons. This is now in the 3000–5000 megawatt-days per ton of fuel element range, F. T. Barr, Esso Research & Engineering Co. reports, and at best has been expected to run about 10,000 mwd per ton. Work by Babcock and Wilcox indicates that by using the "spectral-shift" for control of reactivity instead of

Down to Engineering Details

the more conventional neutron absorption rods, burnups as high as 30,000–45,000 mwd per ton can be achieved. The spectral-shift technique adjusts the velocity distribution of neutrons during their moderation. These were paper studies, but the possibility of achieving such burnups would have a significant effect on the cost of the overall fuel cycle. Per unit of power produced, it would decrease both the fuel element fabrication cost and the reprocessing cost, both of which are very significant at present. The predictions are based only on nuclear limitations, and materials limitations could be important.

Fuel element fabrication cost now seems to be controlling in the overall fuel cycle cost. This was stressed in a paper by W. K. Davis on progress in the AEC program of power reactor development. Recently announced reprocessing prices are estimated by AEC to be the equivalent of ½–2½ mills per kwhr of electric power, depending upon the particular reactor type and cycle used. This apparently puts reprocessing cost in a less critical range than fuel element fabrication cost. The routes for possible improvement in fabrication costs given by Davis were (1) use of homogeneous reactors, (2) increasing the power output per fuel element, (3) increasing the life of the fuel element, and (4) cheaper manufacture.

One of the possibilities in adaptation of nuclear energy to relatively small powerplants such as automobiles has always been the use of heat from the decay of radioisotopes. The Martin Co. Nuclear Division did a feasibility study for AEC on the uses of isotopes for power production. By and large, their conclusion was that this technique is impractical. The cost is excessive and its use would be feasible only for specialized applications of low power output. An example was its use for a "radio beacon" that could be dropped from an airplane in isolated locations to transmit a signal as an aid to navigation. Even for this application, however, isotopic power at best could not be much more economic than the use of batteries.

NAM Policy Statement

At the April 17 meeting of the Nuclear Energy Committee of the National Association of Manufacturers, two proposed policy statements were discussed:

1. Civilian nuclear power reactor development.
   a. Because of abundant U.S. energy sources, nuclear power will not become generally competitive in the U.S. in the immediate future.
   b. The present U.S. program of developing various designs of prototype reactors is sound; "quality" rather than "quantity" development is favored. The group is opposed to accelerated Government support programs on full-scale reactors. The group supported construction and expansion of the existing partnership of Government and industry in research development and testing of various power plant designs as the best way of maintaining U.S. leadership.
2. International aspects of peaceful development of nuclear energy.
   a. Active participation of the U.S. in developing worldwide peaceful uses of nuclear energy is an important and tangible symbol of the U.S. will to peace.
   b. The potential foreign markets are substantial, and must be developed vigorously if the U.S. is to glean its share. This can serve as an impetus for the U.S. reactor industry.
   c. Governmental restrictions on availability of materials for nuclear reactors should be minimized to the extent consistent with the national security, and release of power reactor technology for use abroad should be accelerated.
   d. Implementation of the above views will help U.S. industry develop foreign markets, strengthen mutual security, and underscore benefits of free Government and competitive enterprise.

These statements will later be reviewed for approval by the NAM Board of Directors.

Nuclear Congress Proceedings

The Proceedings of the 1957 Nuclear Congress, held in Philadelphia last March, are to be published on August 15.

They will be published in three volumes, with papers and discussion from the Second Nuclear Engineering & Science Congress in two of them, and those presented at the Fifth Hot Laboratories & Equipment Conference in the third.

If you place your order before August 15, the price will be $35. Thereafter the price will be $45. Send your order to American Society of Mechanical Engineers, 29 West 39th St., New York City 18.

Also available from the ASME is the 2-volume "Selected Papers from the First Nuclear Congress." Price: $28.

Airport Fueling

SAN Francisco International Airport has a hydrant fueling system which might serve as a pattern for the system that will be needed to serve jet transports.

The system provides for hydrant connections at 19 terminal gate positions (Fig. 1). Four grades of fuel are available on the airport with a minimum of two grades at every gate position. A third grade, eventually for jet fuel, will be available at the end positions on the larger concourses "C" and "D". As the airport expands, pipelines will be extended to additional concourses.

The hydrant system has three basic parts.. These are the satellite storage and pumps, pipeline system, and fueling carts.

Satellite Storage

The satellite storage area, located at the north end of the main terminal concourse, comprises eight 400-gpm pumps, filters, and eight 25,000-gal horizontal tanks. These tanks are supplied by pipelines from a 1,400,000-gal main airport tank farm, which, in turn, is fueled by barge from a refinery.

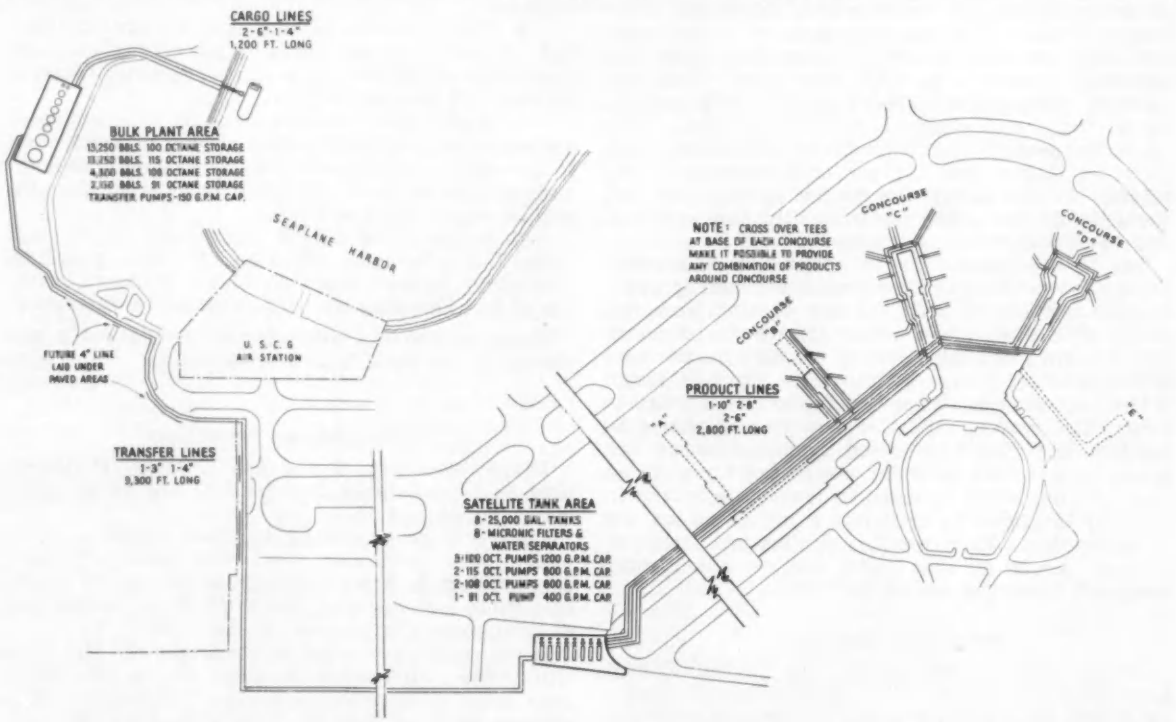

CARGO LINES
2-6"-1-4"
1,200 FT. LONG
BULK PLANT AREA
13,250 BBLS. 100 OCTANE STORAGE
13,250 BBLS. 115 OCTANE STORAGE
4,300 BBLS. 108 OCTANE STORAGE
2,150 BBLS. 91 OCTANE STORAGE
TRANSFER PUMPS-150 G.P.M. CAP.
SEAPLANE HARBOR
U. S. C. G. AIR STATION
FUTURE 4" LINE LAID UNDER PAVED AREAS
TRANSFER LINES
1-3" 1-4"
9,300 FT. LONG
NOTE: CROSS OVER TEES AT BASE OF EACH CONCOURSE MAKE IT POSSIBLE TO PROVIDE ANY COMBINATION OF PRODUCTS AROUND CONCOURSE
CONCOURSE "C"
CONCOURSE "D"
CONCOURSE "B"
PRODUCT LINES
1-10" 2-8"
2-6"
2,800 FT. LONG
SATELLITE TANK AREA
8-25,000 GAL. TANKS
8-MICRONIC FILTERS & WATER SEPARATORS
3-100 OCT. PUMPS 1200 G.P.M. CAP.
2-115 OCT. PUMPS 800 G.P.M. CAP.
2-108 OCT. PUMPS 800 G.P.M. CAP.
1-91 OCT. PUMP 400 G.P.M. CAP.

Fig. 1—Fueling system at San Francisco International Airport provides hydrant connections at 19 terminal gate positions. Four grades of fuel are available, with at least two at each position.

for the Jet Age

Based on paper by **R. H. Barrett,** Standard Oil Co. of Calif.

The satellite facility is divided into four delivery systems; one has a 1200-gpm maximum delivery rate at the terminal concourse, two systems each have an 800-gpm maximum available capacity, while one is a 400-gpm system. This provides a flexible arrangement to accommodate changes in requirements of fuel grades and flow rates. Valves permit individual units to be detached from the system for maintenance purposes.

Some systems have used automatic pump starting by maintaining pressure in the pipelines; the opening of an outlet valve causes a drop in line pressure which starts the first pump. At San Francisco the pumps run only when they are needed. Experience shows that push button starting offers no problems because fueling personnel make it a matter of procedure to depress the pushbutton after making the hydrant hose connection.

A 110-v d-c electrical supply is used for the four starting circuits instead of low-voltage alternating current. This eliminates possible induction problems between starting circuits, as all starting wiring is carried in the same conduit from terminal to relay control panel. Electric controls are located in the satellite area office building.

Pump starting buttons are located at each hydrant outlet valve. The second and third pumps cut in automatically when the demand exceeds 400 or 800 gpm. A combination of mercury pressure switches and pump selector controls, starts and stops the second and third pumps as required to maintain constant pumping pressure. A time-delay switch automatically disconnects the last pump following a 5-min period after fueling has been completed for the particular product involved. This provides sufficient time to gage airplane tanks and to top off at a minimum flow rate.

Each 25,000-gal tank has an outlet valve approximately 6 in. above the tank bottom to provide flooded suction for the centrifugal pumps. A delay opening valve is installed on each pump to prevent initial starting surge pressures.

Pipeline System

Five main supply pipelines carry fuel from the satellite storage to the base of each terminal concourse. Main lines are approximately 2800 ft long and comprise one 10-in., two 8-in., and two 6-in. pipelines. Three 6-in. lines surround each concourse and are connected at each side to the main supply piping. Cross-over tees are located at the base of each concourse on main supply pipelines so that any combination of product can be provided around the concourse. Blind flanges can be inserted between any two adjacent gate positions to permit handling two grades of fuel in a single loop of concourse piping. Thus, four grades of fuel are available through three pipelines on concourse "D."

Four-inch lateral pipelines with plug valves on each line connect to the 6-in. piping surrounding each concourse and extend to each hydrant location. Pressure control valves are located at each hydrant valve connection. Each hydrant coupling is keyed to fit only the particular product in the pipeline, preventing coupling of a fuel cart designated for another grade of fuel. Hydrant and pressure controls as well as vapor-proof starting switches are located at the hydrants in a concrete box flush with ramp paving. A steel cover is hinged so that only a small section need be opened to attach the hydrant cart coupling. A removable steel H-beam supports the weight of surface traffic. The pit provides room for maintenance, adjustment, and for installation of larger hydrants.

Concourse "C" has primary pressure control valves located on each side of the concourse 6-in. pipelines just before connection is made to the main piping. This is less expensive than the individual hydrant pressure control valves provided on concourses "B" and "D," but it is slightly less sensitive to shut-off shock surges.

Hydrant Dispensers

Two types of carts, or mobile dispensing units, are used to satisfy two different service requirements. The trailer-type cart only has hose and ladder equipment with retraction facilities. Motorized units have the same basic equipment and in addition, three 100-gal tanks and delivery systems for aviation oil, antidetonation injection fluid, and sanitary water.

United Air Lines motorized units have a 1½-ton automotive chassis and a top deck with kick-over

Fig. 2—Trailer-type fueling cart modified to use two hoses for fast under-wing fueling.

ladder for fueling 4-engine aircraft. Larger twin-engined aircraft are fueled by standing on the top deck. Fueling equipment comprises a 200-gpm combination micronic filter and water separator, 2½-gal surge suppressor, 200-gpm predetermining meter and air eliminator, and a pressure control and emergency shut-off valve. The emergency valve is solenoid operated by two pushbuttons, one on the top deck and one above the meter which can be operated from the ground position. The power take-off drives three small pumps which dispense Avoil, ADI fluid, and water. A safety device prevents moving the truck until the hydrant hose is disconnected and returned to its proper rack.

These combination fueling units cost less than one-third as much as a fueling truck and replace three other mobile service units wth proportional saving.

Jet Fuel Handling

It is believed that this system can meet all jet fueling needs, although some slight alterations might be needed. The present trailer-type carts could be converted to under-wing fueling (Fig. 2). If the ladder were removed and a second delivery system added, 400–600 gpm could be handled through two hoses and meters from a top deck platform. Numerous versions of carts could be developed to meet particular under-wing fueling needs. A motorized unit with a platform approximately 4 ft above the ground would be ideal. This unit could have metal tubing instead of hose for additional safety. Such a cart could have provisions for dispensing lubricating oil, and a tank and delivery system for engine injection fluid and sanitary water.

Where jet airliners are used for long-range flight, fueling will probably be performed in the maintenance area, with lesser equipment for large volume of fuel at the terminal concourses. In such cases, fuel deliveries will probably not exceed those of present piston-engined aircraft.

Accurate metering of a wide range of flow rates (50–800 gpm) cannot be accomplished with a single meter. But if two meters are used with two hoses on each jet fuel hydrant cart to the two under-wing connections, conventional metering equipment could probably handle flow rates up to 275 gpm through each meter, and for total cart capacity of about 550 gpm, or 1100 gpm if two carts were used.

If maximum rates in excess of 275 gpm are required through a single 2½-in. hose or metal tube, accurate metering could be achieved by the possible use of a combination of two meters, one which would provide acceptable accuracy over a 50–275-gpm range, the other over a range of 250–850 gpm.

Design Considerations

There are four factors of major consideration in the design of a hydrant system. These are: fluid head pressure, fluid velocity, pipeline lengths, and valve closing time.

Fluid head can be determined and controlled accurately by choosing proper pumps and pressure control valves in the pipeline system. Fluid velocity is a function of head pressure and inside diameter of pipelines. Obviously, the larger the pipelines the slower the velocity. Extreme length of pipelines is often a problem because satellite storage cannot be installed close to the terminal areas. Here, consideration might well be given to installing underground tankage and pumps in the open areas between taxiways. In fueling over-wing, valve closing time has been retarded by use of slow-closing hose nozzles and shock suppressors. Closing surge pressures on over-wing fueling can be controlled not to exceed 50% of line operating pressures.

The airplane manufacturer is familiar with the hydraulic limitations of a high-speed hydrant fueling system, and the need for incorporating slow-closing electrically operated tank and main fuel gallery valves. Undoubtedly, these slow-closing valves will be incorporated to protect aircraft plumbing.

(Paper, "Hydrant Fueling," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Based on Discussion by **E. F. Zimmerman,** Shell Oil Co.

IN view of the time required to connect and disconnect four fueling hoses for maximum delivery of jet fuel, and the existing and possible capacity of fueling trucks, it would appear that:

1. Hydrant systems are a definite requirement wherever (maintenance or terminal concourse) the usual amount of jet fuel to be loaded per plane is over 10,000–12,000 gal.

2. Below this figure, cost and convenience will determine whether fueling trucks or hydrants should be used.

The B-52 is the most . . .

. . . lethal and heaviest airplane in the Air Force's inventory. In the 15 years since its conception, this bomber has changed markedly.

Based on talk by **T. E. Gamlen**, chief engineer; **J. J. Clark**, senior project engineer on B-52; **W. E. Burnham**, chief tool engineer, all of Boeing Airplane Co., Wichita

(As reported by Kenneth Rix, SAE Wichita Section Field Editor)

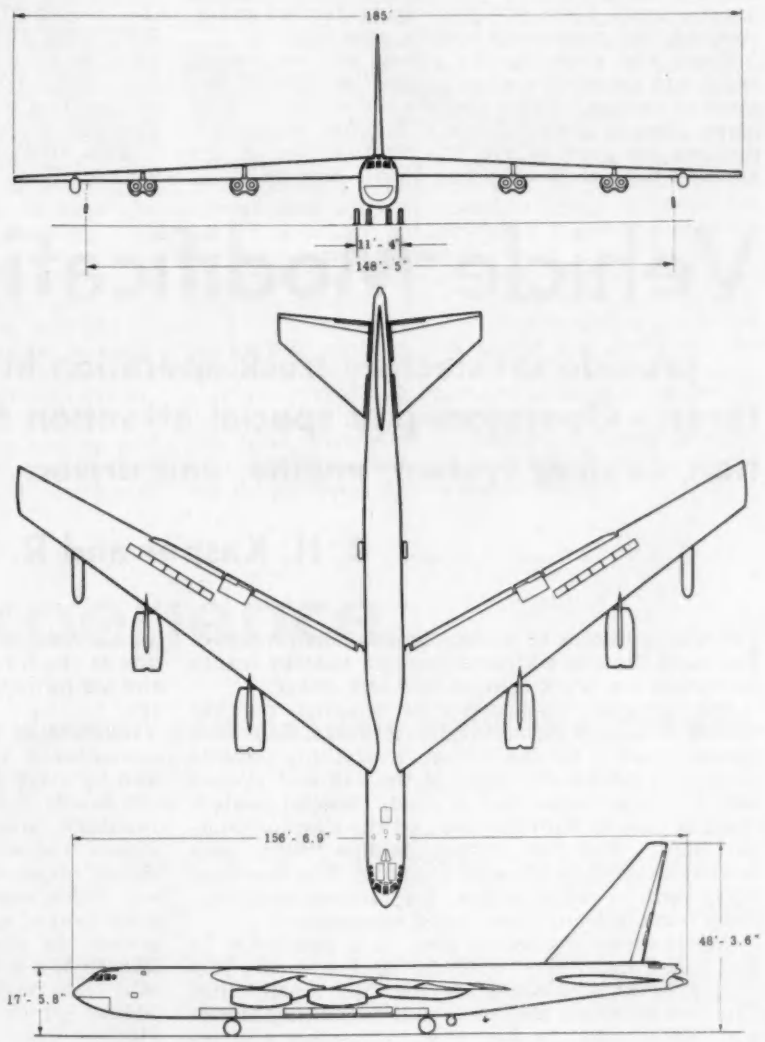
THE necessity for intercontinental bombers was established in 1941; the basic requirements for the B-52 were developed in 1946. At that time Boeing started on a program to study the strategic problem with requirements set up by the Air Force.

The airplane in their minds at that time looked nothing like the B-52 does today. Turboprops and reciprocating engines were in vogue then, and no consideration was given to swept wings at that time. Once desirability of swept wings was proved on the B-47 and large jet engines arrived, it became apparent that they had some real possibilities. At this same time in-flight refueling appeared as a definite possibility. These things added up to fulfilling the objective of the Air Force.

In 1948 the airplane assumed the basic configuration it has today, and in 1949 Boeing was authorized to build the first two airplanes. In April, 1952, a prototype was flown. By 1954 B-52's were in production, and in 1955 were being delivered to Strategic Air Command Bases.

Geometrically the airplane looks much like the B-47, but it is much larger. The gross weight is over 400,000 lb; the wing span is 185 ft; the body length is 156 ft; the stabilizer span is 52 ft; and the top of the fin is 48 ft above the ground line. Despite its size, it is a clean airplane and flies and handles nicely.

The original basic airplane took over 3,000,000 man-hr to produce the design drawings and data. There are over 105,000 different parts excluding bolts, rivets, and other standard parts, and 25,000 drawings in one set of blueprints, which would fill about 46 four-drawer files.



Drawings of B-52 airplane developed by Boeing for the Air Force.

The main landing gear consists of two duals in front and two duals in the rear, or eight main wheels. The right gears (front and rear) fold aft and up and the left gears fold forward and up. The airplane normally rides on its main landing gear. The outrigger protection gear, located on the outboard wing, normally clears the ground by about 24 in.

A pneumatic system constitutes the auxiliary power supply in the airplane. Bleed air from all the engine compressors is ducted into main distribution ducts, which go down the wings and through the full length of the fuselage. This air is tapped to operate the water pumps for water injection into the engines, the air conditioning equipment for the crew stations, four 60-kva electric alternators to supply the main electrical power for the aircraft, and 10 hydraulic power packs. Hydraulic power is used to operate the stabilizer, landing gears, brakes, bomb doors, spoilers, tip protection gears, steering, and cross-wind landing gear trim.

There are seven spoiler panels on each wing, which are raised to various angles for different degrees of control. These spoilers are designed to be blown down by the air stream if they are overloaded. Spoilers are used to aid the effectiveness of the ailerons because Boeing has found that in using flexible wings at high speeds ailerons act as trim tabs and twist the wing, thus reversing the control.

The B-52 uses eight Pratt & Whitney Aircraft J-57 engines mounted in pods beneath the wings. Boeing cites many advantages of mounting engines there, such as low drag, isolation from primary structure, and ease of maintenance.

One of the big problems on the B-52 has been the high sound level, with its corresponding high sound pressure. This fluctuating pressure has actually cracked skins. Boeing checked into the relative fatigue life of different structures and found the general practice of riveting stiffeners to skins worst. Skins bonded to stiffeners were better by approximately 200%, but honeycomb structure was the best by approximately 500%.

The tooling of this airplane posed many problems, one of them being tolerances. A typical example is the inboard wing panel jig, which is approximately 100 ft long and yet holds tolerances of plus-minus 0.030 in. on most dimensions. On large assembly jigs, reinforced concrete was used for basic support, yet jigs had to be light enough to move out of the way when Boeing goes to bigger and faster airplanes.

(This abridgment is based on talk, "The Boeing B-52 Airplane," presented at SAE Wichita Section.)

Vehicle Modifications . . .

. . . provide satisfactory truck operation in Alaska's low temperatures. Operators pay special attention to fuel supply, lubrication, cooling system, engine, and driver.

Excerpts from paper by **R. H. Kasper and R. C. Norrie,** Kenworth Motor Truck Co.

TRUCK operators in Alaska modify their vehicles to meet the low temperatures and thereby insure protection for truck components and driver.

The extreme Alaskan winter weather requires special treatment on certain truck items, as well as special clothing for the driver. Everything possible is done to adequately insulate the cab and sleeper box, where a sleeper box is used. Special heaters must be used in both the cab and the sleeping compartment. For the drivers, besides being very heavily dressed in all-wool clothing, it is standard equipment to carry parkas, fur mittens, and fur-lined boots for any unexpected emergency.

Where diesel trucks are used, it is customary to run a hot water line from the engine to the fuel supply tanks and alongside the fuel supply line. The fuel tanks are also encased in insulating blankets. This keeps the fuel from congealing and reduces condensation caused by different ambient and fuel temperatures. Alcohol or Ban-Ice is added to the fuel, using approximately 1 pt per 100 gal of fuel. These liquids absorb condensation in the fuel tanks and prevent freezing in the fuel lines. Alcohol vaporizers are used on the intake side of the air compressor to prevent condensation and ice formation in the brake lines and brake valves.

Lubrication is one of the most serious problems encountered by motor freight haulers during extremely cold weather. Temperatures range from – 30 to – 70 deg in the interior of Alaska and Yukon Territory, and proper lubrication of gear boxes, wheels, and other moving parts of the vehicle was almost impossible until recently. It is still a problem which requires special lubricants as well as a great deal of special attention and precaution. Operators, in general, use the following lubricants: SAE 20 Motor Oil for engines; SAE 90 Gear Lubricant for transmissions and rear ends; Aviation Grease #1 for wheel bearings; and SAE 75 Multi-Purpose Gear Lubricant for the steering gear.

One of the really serious problems is the lubrication of wheel bearings. The vehicle may be sitting in heated garages or it may be travelling from the coast, where the temperatures are freezing or slightly above, and go into the interior, where the

temperatures often are – 50 or – 60 deg. This results in condensation in the hubs which, in turn, results in etching or rusting of the wheel bearings. The use of Aviation Grease #1 as wheel bearing grease has contributed materially toward eliminating this etching and rusting condition.

Care must be taken to prevent overcooling the engine, since a large part of the engine heat rejection is being used to keep the drivers and the fuel warm. Thermostatically controlled fans and shutters are an absolute necessity and it is wise to have an adjustable canvas winter front in addition. Insulated or heated battery boxes were used quite extensively some years ago and are still used to some extent, but in general this method has been discontinued. The heavy case and mass of the battery, plus the heat of charging, seems to keep the batteries warm enough without additional protection.

The cooling system is protected during the winter with a 50/50 solution of ethylene glycol and water, which has almost entirely eliminated any cooling system problems. However, everything possible is done to prevent letting the unit stand for more than an hour or two during extremely low temperatures.

Most of the equipment operating on the Alcan highway is equipped with sleeper boxes and is operated by two drivers. By alternating between driving, sleeping, and eating, equipment is kept operating a large part of the time and standing time is cut to a minimum.

Motors are never shut down unless it is absolutely necessary. An engine sometimes runs for as long as a week without ever being shut down, and the oil is checked and added with the engine running. About the only time that an engine is shut down in extremely cold weather is at one terminal or another where help is readily available in case the engine fails to start. The charging system and batteries must be kept in perfect condition. Electric starting is impossible in extremely cold weather if the batteries are too cold or not fully charged.

Danger of channeling grease in the transmissions or differentials is very great if equipment is allowed to stand overnight or for any length of time in extremely low temperatures.

If it does become necessary to let the vehicle stand overnight or for long periods in extremely low temperatures, the engine should always be preheated when the ambient temperatures are lower than – 5 deg. Transmissions and rear ends should be preheated if the temperature drops lower than – 20 deg. Wheel bearings should be preheated by warming the hubs if the temperature drops lower than – 35 deg.

Where engine heaters of the aircraft type are available, trucks are usually covered completely with a tarpaulin and the complete unit is heated with hot air. Often, lubricants in the engine, transmissions, axles, and steering gear are drained when long stops are anticipated. Warm lubricants are used as a refill before the vehicle is again put into operation. As long as the vehicle is in operation lubrication temperatures seem to reach and keep close to normal operating temperatures.

Trucks on long trips always carry blowtorches and kerosene weed burners for preheating operations. In extremely low temperatures the kerosene forms crystals and will not normally ignite in the weed burner, therefore the blowtorch is used to preheat the weed burner so that it can be placed in operation to preheat the truck before starting and running the vehicle. The gasoline blowtorch is also used to warm hand tools when emergency mechanical work is required. All trucks also carry the indispensable snow shovel.

(Paper, "Trucking Problems in Alaska," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Pontiac Experience . . .

. . . yields comparative data on cast pearlitic malleable iron and forged steel crankshafts.

Based on paper by **K. B. Valentine,** Pontiac Motor Division, GMC

PONTIAC has had enough experience with pearlitic malleable iron in the crankshaft of its 316 cu in. V-8 engine to make comparisons with previous experiences with crankshafts forged from SAE 1046 steel, water-quenched and tempered to 228–269 Brinell. Also, it has learned many specific characteristics of the newer material in this crankshaft application.

1. Test pieces of the iron, machined from various positions on finished crankshafts, show a lower modulus of elasticity than steel's 29,500,000 psi (Table 1).

2. The differently designed forged and cast crankshafts have similar torsional vibration characteristics.

3. The forged and cast crankshafts show comparable endurance. (A year's field experience confirms

Table 1—Results of Elastic Modulus Determinations

Specimen No.	Elastic Modulus, psi
1	26,200,000
2	24,300,000
3	25,400,000
4	25,200,000
5	26,700,000

Table 2—Results of Fatigue Tests Run on Test Bars with Various Notch Contours

(Hardness of test bars was 207-217 Brinell)

Notch Radius, deg	Cycles to Failure
10	6,720
10	7,560
10	7,560
10	8,400
20	14,280
20	11,760
20	6,720
20	6,720
20	6,720
20	6,720
20	5,880
30	7,560
30	6,720
30	6,720
30	5,880
30	10,920
30	9,240
30	8,400

Table 3—Effect of Cold-Work on Impact Fatigue Property of Pearlitic Malleable Iron

Treatment	Cycles to Failure
(1). Air-quenched and tempered	6,720
	7,560
	7,560
	8,400
Same as (1) above except test bar notch coined 0.001.	14,100
	42,840
	55,440
	42,000
(2). Oil-quenched and tempered	10,080
	11,760
	10,920
	7,560
Same as (2) above except test bar notch coined 0.001.	14,280
	23,520
	19,320
	11,760

earlier dynamometer and 100,000-mile car tests on this point.)

4. No effect of variations in notch sharpness on fatigue properties of pearlitic malleable iron are discernible in tests (Table 2).

5. Tensile strength is somewhat less than that of the steel crankshafts. (Standard ASTM 0.505-in. tensile test bars, machined from journals and counterweights of cast crankshafts, showed 96,000 psi tensile strength at 228 Brinell hardness. The SAE 1046 steel forged crankshafts showed 114,000 psi at 228 Brinell.

6. Pin and journal sections of pearlitic malleable iron crankshafts are reasonably uniform as to Brinell hardness. (Hardness of journal cross-section generally is 217–229 from center to surface.)

7. There is no appreciable difference in pin and journal wear of cast as compared to forged crankshafts.

8. For the same hardness level, oil-quenched and tempered pearlitic malleable iron has slightly better fatigue properties than the same material when air-quenched and tempered (Table 3).

9. Definite machining economies have resulted from use of the cast crankshafts.

Machining Economies

Pontiac production department reports indicate that these machining economies are appreciable as compared to machining on SAE 1046 steel crankshafts. These reports—based on one month's production when 59,000 forged crankshafts were machined and on one when 49,000 cast crankshafts were machined—reveal the following economies accruing from use of the pearlitic malleable iron units:

- Tool life increased 56%.
- 21 tools required for forgings; 6 for castings.
- 58% better tool life.
- Life of 0.246-in. drill increased 147%.
- Life of 0.250-in. drill increased 267%.
- Tap life increased 217%.
- 47 wheels used to grind 59,000 forged crankshafts; 27 wheels to grind 49,000 cast ones.
- Feed rate of several machines increased on cast units.

The crankshaft forging weighed 77½ lb as received, and 59½ lb when machined. The casting weighed 64 lb as received, and 54 lb when machined. More metal, in other words, had to be removed from the forging than from the casting.

(Paper, "Some Metallurgical Aspects of Pontiac V-8 Engine Pearlitic Malleable Iron Crankshaft" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Cleanliness is primary goal of . . .

New Turbine Fuel Handling Techniques

Based on paper by **W. S. Little, Jr.,** Shell Oil Co.

THERE are three basic requirements for airport turbine fuel storage facilities, all of which have as their objective the supplying of uncontaminated fuel to coming turbine-powered commercial airliners. These are:

1. Give the fuel time to settle out particulate contaminants.
2. Draw the fuel off the top of the tank via floating suction.
3. Use a combination water separator and micronic filter.

Settling rates of particles, both liquid and solid, are roughly inversely proportional to the absolute viscosity of the fuel involved. Aviation turbine fuel of 0.80 sp gr requires approximately four times as long to settle as aviation gasoline to permit comparable levels of particle drop-out. Water drop-out is at a lower rate, a 30-micron droplet taking one hour to descend one foot. The generally accepted industry standard for settling time of aviation gasoline is 15 min per ft of depth, hence aviation kerosene should be permitted to settle a minimum of 1 hr per ft of depth. JP-4, with somewhat lower viscosity, will require less time.

Once storage assures adequate settling time, all product should be withdrawn from storage through a floating suction to avoid using bottom product which may not have settled sufficiently, and to prevent reintroduction of settled contaminant. Floating suction is the only logical way of taking full advantage of gravity in removing water and particulate matter contamination. The floating suction should be provided with a cable to check free operation.

The combination water separator and micronic filter, the third important component, should be located in the storage system in a manner to cause the fuel to pass through the unit both on the way to storage and on the way from storage to the dispensing equipment.

Storage Facilities for Viscount Operation

The basic installation developed by Capital Airlines for Viscount operation is normally two 15,000-gal tanks at smaller stations with increased sizes and more tanks at larger stations. This is not strictly speaking a two-tank system because the installation does not require duplication of all components. For example, one water separator—micronic filter unit is sufficient. It is believed to be the most effective way of insuring adequate settling time without placing undue burden and responsibility upon ground personnel.

A large single tank would do the job if adequate settling time were provided. Either the tank could be divided into compartments, or it could be blocked off from use after filling while the settling takes place. The latter is not feasible. Moreover, if gross contamination occurs, all supplying of fuel is stopped.

If space is the problem, then the large compartmentalized tank appears logical. If cost is the reason, it will be found that the flexibility of multiple tanks far offsets the slightly added cost.

If one is thinking of equipment for the larger airports, it should be borne in mind that 30,000 gal is optimum size for an underground tank. Larger tanks should be installed vertically above ground, and should have a floating roof to decrease vapor space and reduce fire or explosion hazard. All types of storage tanks should be equipped with submerged inlets with deflectors and with couplings or tight fill connections for unloading. These units limit vapor loss, agitation of tank bottoms, and the possibility of ignition by static electricity.

Installation Costs

Costs depend on local conditions, but the Capital installation comprising two 15,000-gal tanks, filters with heating provisions, and nominal labor expenses, would cost between $15,000 and $20,000. These installations can be constructed for as little as $12,000 or as much as $25,000, with $18,000 as the average, with estimates based on 1956 labor and parts costs. These costs have been itemized in Fig. 1 and may be extrapolated for installations up to

approximately 120,000-gal total capacity. But costs for stations such as Idlewild or Chicago cannot be assessed.

Dispensing Equipment

Regardless of the type of dispenser used, we do not expect any major changes in future hydrant carts, pits, or refuelers from those with which everyone is familiar. Every attempt should be made to use current equipment at least in the initial phase. By 1959–1960 the airlines can be provided with the 300-gpm hose target which they have established generally as their maximum requirement.

From the cleanliness standpoint, we expect the storage system to have provided the necessary quality of fuel. All that is needed is observance of good practice, and the installation on the dispensing equipment of a proved micronic filter having water-coalescing capabilities at the flow rates involved.

(Paper "Turbine-Powered Aircraft Demand New Fuel Handling Techniques" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Based on Discussion

P. Lamoureux

Trans-Canada Air Lines

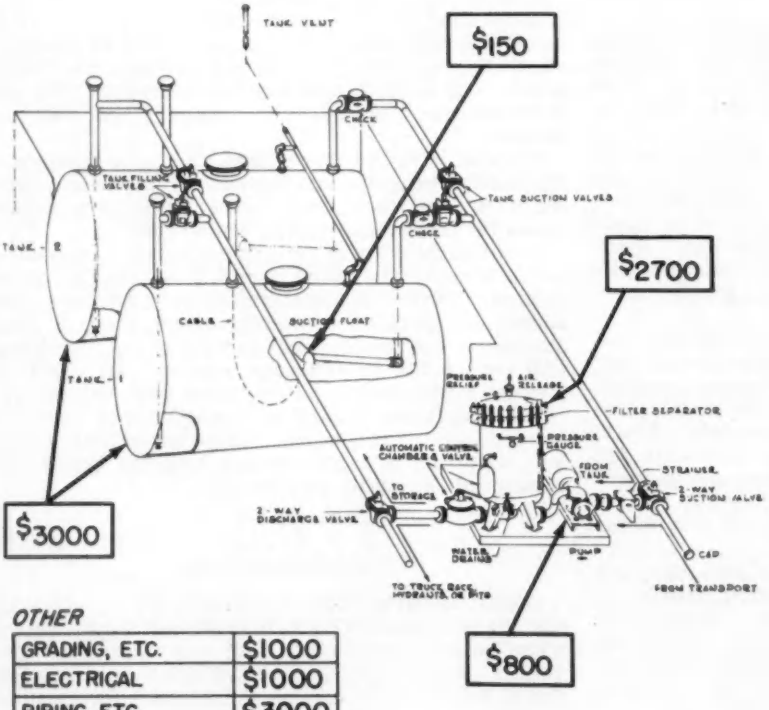
Adequate settling periods and the use of floating suctions become increasingly important in colder climates where the viscosity and gravity of the fuel mitigate against the rapid settling of particulate matter and water. Recent information indicates that while 1 hr per ft of depth settling period is suitable for gasoline, it is entirely inadequate for JP-4 and especially kerosene turbo fuels.

Analysis of dirt found in aircraft fuel systems shows rust to be one of the major components. This suggests the possibility of coating airport storage tanks to eliminate completely the airport storage system as a source of abrasive rust and mill scale. Such coatings are available and have proved successful in ship tanks, refinery storage, and oil trucks.

F. W. Cayea

California Texas Oil Co.

Since it is impractical to have an efficient device at the end of the hose to insure fuel cleanliness and dryness, it would seem highly desirable to locate a separator/filter which would meet the 8508 specifications on the fueling truck or hydrant cart. Several "secondary" filter/separators are available that perform in similar manner but fall short of the same degree of protection. There is considerable need for high-flow separator/filters small enough for installation on mobile equipment, incorporating slug control, automatic dump, and shut-off equipment, and efficient enough to meet 8508 specifications fully.



OTHER

GRADING, ETC.	$1000
ELECTRICAL	$1000
PIPING, ETC.	$3000
TANK INSTALLATION	$3000

Fig. 1—Estimated costs of the 30,000-gal storage system used by Capital Airlines for its Viscount operation. Costs of the major components may be extrapolated for installations up to 120,000-gal total capacity.

SAE National Meetings

1957

September 9-12
National Farm, Construction and Industrial Machinery Meeting and Production Forum

September 30-October 5
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

1958

January 13-17
Annual Meeting and Engineering Display, The Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

March 31-April 2
Production Meeting and Forum
The Drake, Chicago, Ill.

March 4-6
Passenger Car, Body, and Materials Meeting
Sheraton-Cadillac Hotel, Detroit, Mich.

April 8-11
Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display
Hotel Commodore, N. Y., N. Y.

June 8-13
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N.J.

August 11-14
West Coast Meeting
The Ambassador, Los Angeles, Calif.

Plans Already Underway For April Aeronautic Meet

G. N. Cole

TECHNICAL sessions planned for the April 1958 SAE National Aeronautic Meeting will provide members with the information most timely next spring.

With suggestions from SAE's three aeronautic Activity Committees, the Executive Committee for the Meeting has compiled a list of "major technical problem areas," and Committeemen are actively searching out sources of information on them. These areas include:

- Turbine fuels and lubricants
- New sources of energy for propulsion (especially boron fuels)
- Maintenance problems encountered in turbine-type-powered aircraft
- Powerplant control systems
- Rocket powerplants
- Small turbine powerplants
- Descriptions of new turbine engines
- Imaginative airport planning for jets
- Navigational instruments for jet aircraft
- Air traffic control
- Application of computers to air transportation operations
- Supersonic transports
- VTOL and STOL developments
- Problems of very high speed flight—Mach 15 and higher
- Sound suppressors and jet reversers
- Jet transport piloting techniques

Offers of papers available, and leads on research which might yield papers, can be sent to the Executive Committee in care of SAE headquarters. Such material will be considered at the Executive Committee meeting on August 22.

Consideration of the problem areas brought out a wealth of engineering shop talk on such subjects as high-energy fuels at the Executive Committee's first meeting. Boron seems to be the leading contender among the metallic fuels, it was noted, although aluminum, magnesium, and lithium are still under study. All of them may be burned as gases, liquids, solids, or in slurries of other flammable liquids such as JP-4. Weapon system vehicle WS 110 is one already announced as being designed to use boron-type fuels.

Some airlines engineers go so far as to predict that the next round of transports will use some form of high-energy fuel. Such fuel may make supersonic transports feasible—but the airlines don't foresee supersonic travel until the day when it costs substantially the same as subsonic travel does now. (See page 17 for additional information on new sources of propulsion energy presented to the Committee.)

Advances in vertical and short take-off and landing (VTOL and STOL) aircraft may change the whole current concept of airport design in 10 years or so, one Committeeman noted. Major airports may be located 100 miles or so from the cities they serve, and be linked to them by helicopter lines.

"Magnetoaerodynamics" (or "magnetohydrodynamics"), it was reported to the Committee, is an extended branch of aerodynamics resulting from the fact that: "As air particles pass through the shock wave associated with a blunt body such as a missile traveling at Mach 15–20, their kinetic energy is converted to thermal energy. Temperatures in the range of 5000–7000 K result. This dissociates and ionizes the components of the air. The intense relative motion of the ionized particles sets up an electromagnetic field which reacts on the conducting fluid, thereby altering its motion.

"Therefore, in studies of Mach 15–20 fluid dynamics, the conducting fluid and electromagnetic field have to be treated along with the forces usually considered in classical hydrodynamics."

Gilmoure N. Cole, chief of engine design for Pratt & Whitney Aircraft, is general chairman for the April 1958 Meeting. Present on June 17 at the first meeting of his Executive Committee were: Anderson Ashburn, "American Machinist;" M. G. Beard, American Airlines; Wilgus Broffitt, Allison; T. M. Dunn, Pan American-Grace Airways, Inc.; G. W. Gilmer, Arabian American Oil Co.; A. T. Gregory, Fairchild Engine & Airplane Corp.; Hugh Harvey, Shell Oil; Jack Lipman, Republic Aviation; E. J. Manganiello, NACA; D. Q. Marshall, General Electric; W. W. Thomas, Vertol; K. F. Wazmuth, Republic Aviation.

Briefs of SAE PAPERS

Presented below are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. Order from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each to members, 60¢ each to nonmembers.

AIRCRAFT

Problems in Application of High Strength Steel Alloys in Design of Supersonic Aircraft, A. F. ENSRUD. Presented Apr., 1957, 42 p. Problems resulting from increased temperature associated with high speed flight investigated at Lockheed research laboratory; means available for solving such problems for structures flying in intermediate hypersonic range; subject considered under three headings: aerodynamic heating, structural configurations for thermal flight, and production problems.

Application of Chem-Mill to Airframe Structures, L. G. HALL. Presented Apr., 1957, 6 p. In addition to saving weight, Chem-Mill process, developed by North American Aviation, has many other advantages; applications to machining after forming, honeycomb sandwich construction, and tapering of skins and extrusions; reduction of welding problems; cost savings; limitations; process not recommended for use on castings.

Jet Engine Control, R. E. LEDBETTER. Presented Jan., 1957, (Metropolitan Sec) 12 p. Development of control system with particular reference to General Electric Integrated Electronic Control, used on engine models J47-17 and J47-33; steps in design; how electronic approach offered best mechanization for truly integrated control with degree of accuracies needed and types of coordinated functions to be performed; operation of control and major components.

Tilt-Wing VTOL Aircraft as Commercial Air Transport, F. R. MAZZITELLI. Presented Feb., 1957, 17 p. Need for short haul commercial air transport capable of vertical takeoff and landing and having high cruising speed led to development of turboprop tilt-wing VTOL aircraft; reasons for selecting tilt-wing type; comparative study of direct operating cost of comparable helicopter and fixed wing aircraft with VTOL; comparison of block time and block speed; operational aspects; advantages and disadvantages for both commercial and military operations.

Engineering Design for Human Limitations, J. D. CALDARA. Presented Apr., 1957, 5 p. In examining accidents and operation of supersonic aircraft in terms of cause factors, human error is of critical importance forcing human to perform in situations demanding more than he is capable of responding to; man and machine must be considered integral unit; design limitations of human portion of man-machine complex should be given same attention as those of machine; plea for development of anticollision devices and better control equipment.

Human Factors in Design of High Performance Aircraft, R. B. CRISMAN, C. L. FORREST. Presented Apr., 1957, 8 p. Three most important human factors, pressurization, respiration, and temperature, are considered under routine or normal flight conditions from engineering and aero-medical point of view; how they affected current aircraft with performance capabilities ranging from current series fighter to speed regime within aerodynamic flight limits, how they will affect future design and how they can be solved.

Air Operations Problems in Vicinity of Metropolitan Areas, C. E. ROSENDAHL. Presented Apr., 1957, 18 p. Based on investigations undertaken by National Air Transport Coordinating Committee, causes of community objection to air terminal operations are examined; noise and fear of accidents are prime causes, but common denominator is lack of public understanding of airport and flight operations; need for aviation education program in airport terminal areas is pointed out; jet noise and development of noise suppressors.

Accessories for High Mach No. Engines, J. D. DELANO. Presented Apr., 1957, 19 p. Review of development of accessory drive devices; thermal problems of high speed flight affecting accessory systems and methods of overcoming them in aircraft and engine systems; as optimum solution to problems, it is proposed that all aircraft and engine accessories not absolutely necessary to engine be located in package in wing; accessories will be mounted on gearbox, driven by power transmission shaft running through strut; design considerations, and advantages.

Automatic Flight Control Systems Requirements for High Performance Fighter Aircraft, N. GROSSMAN. Presented Apr., 1957, 6 p. New design philosophy is that controls and other functional systems, formerly designed separately or by different subcontractors, must be treated as one complete flight control system with aircraft itself to insure acceptable flying conditions over entire mission profile; requirements of automatic systems designed on this basis; consideration of piloted loop and of automatic loop.

GROUND VEHICLES

Station Wagon, G. F. MACFARLANE. Presented Feb., 1957, (Detroit Sec) 5 p. Experience of Mitchel-Bentley Corp. with problems relating to body design and structure of station wagons which must be completely functional in performance and appearance, i.e., utilitarian yet esthetic; example of conversion of 2-door parts for use on 4-door wagon; conversions involving spliced roofs; changes to floor pan; difficulties in designing rear end structure; possible combinations in tail and lift gate conditions; other engineering problems in design.

Application of Fuel Injection to Ordnance Gasoline Engines, W. F. ISLEY. Presented Feb., 1957, (W Michigan Sec) 23 p. SU fuel injection system as applied by Continental Aviation to Ordnance aircraft engines is basically type originally developed by SU Carburettor Co, Ltd; application to engines for ordnance vehicles; requirements and specifications; table of ordnance gasoline engine models; octane and metering requirements; temperature and altitude compensation; performance comparison of carburetor vs injection engines.

Torque Converters Can Be Different, J. B. BLACK, M. W. DUNDORE. Presented Mar., 1957. (Earth Moving Industry Conference, Peoria, Ill.) 42 p. Basic differences of various types and comparison in terms of fundamental characteristics when combined with typical internal combustion engine power source; evaluation of types can be done by mathematical determination of earthmoving vehicle performance derived from use of various converter absorption and power transmission characteristics.

Development of New International Payhaulers, K. J. KOLINGER. Presented Mar., 1957, (Earthmoving Industry Conference, Peoria, Ill.) 10 p. As results of survey and field representations in various parts of country, undertaken by Construction Equipment Div of International Harvester Co, desirable specifications of off-highway trucks were formulated which led to final development of Model 95 and 65 Payhauler having 24-ton and 18-ton payload respectively.

Terrain Evaluation in Automotive Off-The-Road Operations, M. G. BEKKER. Presented Mar., 1957, (Earthmoving Industry Conference, Peoria, Ill.) 27 p. New approach to problem of land locomotion under vehicle action confirmed experimentally by Land Locomotion Research Branch of Tank Automotive Command in Detroit, led to establishment of general semi-em-

pirical principles to solve plasticity problem; application to 13 examples encountered in earth moving, logging and agricultural operations; advantages of proposed soil values system in study of off-road locomotion.

Army's Wheeled Vehicles, J. J. WILSON. Presented Mar., 1957, (Earthmoving Industry Conference, Peoria, Ill.) 5 p. Similarities between earthmoving and military vehicles; army vehicles used in battlefield, distribution, and logistic roles, ranging from ¼- and ¾-ton rated capacities, 2½-ton trucks, and to limited extent 2½- and 5-ton tractors respectively; based on 14 mo of investigations desirable features of military vehicles within limitations of civilian solutions are enumerated.

Developments in Off-Highway Vehicles, E. R. STERNBERG. Presented Feb., 1957, (Philadelphia Section) 17 p. Vehicles used for construction purposes and basic earthmoving operations; rear dumpers of rubber tired type; development of components during past 20 yr refer to engines, torque converters and transmission, axles, bodies and hoists; available models of fixed and articulated type, exhibited at Road Show, such as Dart, Euclid, Harvester, Kenworth, Mack, Autocar Model AP25, etc; illustrations.

System of MWM Balanced Pressure Precombustion Chamber for High Speed Diesel Engines. Presented June, 1957, 15 p. New system, developed by Motoren-Werke Mannheim, AG, Germany, by means of which it is possible to obtain considerable tolerance in variation of fuel for air and water cooled engines; comparison of combustion process of three diesel engines fitted with swirl chamber, direct injection, and new combustion system; performance of engine when different fuels are used; characteristics and advantages.

MATERIALS

Development of Modern High Vanadium Die Steel, P. R. BORNEMAN. Presented Mar., 1957, Buffalo, N. Y. 2 p. Experimentation at Allegheny Ludlum's Tool Steel Research Section to find steel which would resist galling and seizing in deep drawing operations, and development of alloy, known at Ottawa 60, containing 12% vanadium; use of packing material; how to overcome difficulties in sawing and finish grinding; development of graphitic high carbon-high vanadium steel.

ALSO AVAILABLE . . .

. . . 1957 SAE NATIONAL AERONAUTIC PRODUCTION FORUM, presented April 2. Secretaries' report of 6 panels on "Industrial Readiness," "Shortening The Lead Time Cycle," "Manufacturing Facilities for Tomorrow," "Manufacturing Research," "Developing Human Resources for Production," and "Product Reliability." Available as SP-319 from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.

Free-Piston Engine Has Substantial Advantages

Based on talk by

A. L. LONDON,
Stanford University

A review of recent free-piston-engine developments shows that:

1. The free-piston and turbine compound engine has the substantial advantages of improved specific weight and compactness, mechanical simplicity, the excellent torque characteristics of a separate power turbine, and virtually instantaneous response to throttle changes; all coupled with a fuel economy comparable to that of a diesel engine.
2. Because of the severe top ring problem, satisfactory operating pressure ratios are currently less than 5/1.
3. Trends in free-piston-engine development are expected to be in the direction of (a) higher supercharge pressure ratio as limited by top ring developments; (b) variable nozzle area turbine to improve part-load economy; and (c) multiple-barrel units of smaller capacity per barrel to obtain the advantage of reduced development costs and improved specific weight.
4. The remarkable progress of free-piston-engine development in this country in the past three years suggests that this engine concept is finally over the "hump." To the Mar-

Continued on page 98

Tire Noise Is Not Major Operator Gripe

Based on paper by

T. A. ROBERTSON
Firestone Tire & Rubber Co.

TIRE noise is really a minor consideration from the standpoint of the truck driver and operator. (They're concerned chiefly with in-the-cab noises.) Reasons for the operator's lack of concern with tire noise are several. Among them:

1. Volume of tire noise heard within the cab is small compared to that from other sources.
2. Noise heard when coasting is so much less than with the engine running that the driver rarely notices tire noise even then.
3. Even rather noisy tires often elicit praise from a truck driver because he gets a feeling of safety from the "sound of traction."

Many recent changes to improve tread wear, however, have helped to reduce tire noise, too.

As trucks become more powerful and roads get smoother, the tire engineer is faced with increased traction requirements for highway truck tires in particular. . . . And his problem is to provide more traction without introducing uneven wear, vibration, and noise.

(Paper "Truck Tire Noise" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Air Conditioned Cars Must Handle Fuel Better

Based on paper by

J. G. Lillard and T. G. Lipscomb
Humble Oil & Refining Co.

INSTALLATION of air conditioning on cars imposes serious volatility limitations on the fuel (installation of the unit lowers car volatility Rvp limits 0.6 psi, on the average; operation of the unit lowers it another 1.3 psi). The effect is to limit the allowable butane content of the fuel, which, in turn, increases production costs.

Hope for alleviation of the situation seems to lie, so far, in the following facts:

1. Cars with 4-barrel carburetors have a 5-psi Rvp volatility advantage over the same cars with 2-barrel carburetors.
2. The development of more compact and efficient compressors for air conditioners should improve ventilation and cooling ability of the fuel handling system.
3. The knowledge of how to combat the problem is available, for each of the major manufacturers has at least one car that offers excellent vapor-lock protection. If the improvements in these cars can be transferred to the companion makes in each company, the present overall trend toward increasing vapor-lock tendencies could be reversed.

(Paper "Hot Fuel Handling Characteristics of 1956 Cars With & Without Air Conditioners" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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NATIONAL Farm, Construction and Industrial Machinery MEETING and PRODUCTION FORUM

(FORMERLY SAE NATIONAL TRACTOR MEETING AND PRODUCTION FORUM)

September 9-12, 1957
Hotel Schroeder
Milwaukee, Wisconsin

PRODUCTION FORUM

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. . . Heat Treating Techniques
. . . Small Gasoline Engine Manufacturing Techniques
. . . Production Planning and Inventory Control
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. . . Hydraulic Systems and 3-Point Hitch

LUNCHEON

featuring . . .

. . . "The Wild Blue Yonder,
Or Who Is Doing What to Whom"
Herbert A. Leggett—
Vice-president and economist,
Valley National Bank, Phoenix
Editor, "Arizona Progress"

ANNUAL GOLF TOURNAMENT

. . . Ozaukee Country Club, Thiensville, Wis.

S·A·E CEP
COOPERATIVE ENGINEERING PROGRAM NEWS

CRC Presents Three Ways To Detect Surface Ignition

DETECTION of surface ignition by three methods of instrumentation is described in CRC report 304, "Combustion-Chamber Deposits—Instrumentation." Advantages and disadvantages of ionization gap, pressure-time, and rate-of-pressure rise instrumentation are reported by nine laboratories where testing occurred.

In developing each of these instrumentation procedures, deposit-induced surface ignition is recorded by photographic and counting techniques. The photographic technique, however, can give more complete information about events taking place within the combustion chamber. It requires film processing and extensive data analysis. On the other hand, instantaneous results can be obtained by using the counting technique.

Ionization Gap Advantages

• Ionization gap pickup can be made small enough to fit many combustion chambers where pressure-time and rate-of-pressure rise pickups will not fit. (See Fig. 1)

• Since there is less circuitry and no photography required, surface ignition detection is easier to count.

Disadvantages are: Ionization gaps can become fouled with deposits unless proper design is used; a separate hole is required in the combustion chamber; location of ionization gap in combustion chamber is critical; and severity of surface ignition is not reliably established because the technique can only detect flame front arrival at ionization gap.

Pressure-Time Instrumentation Advantages

• The Li-type pickup developed by Dr. Y. T. Li of M.I.T., contains a spark plug. Thus, the need for an extra hole in the cylinder head is eliminated.

• More complete information on the combustion process can be obtained.

• Surface ignition severity may be measured in contrast to the ionization

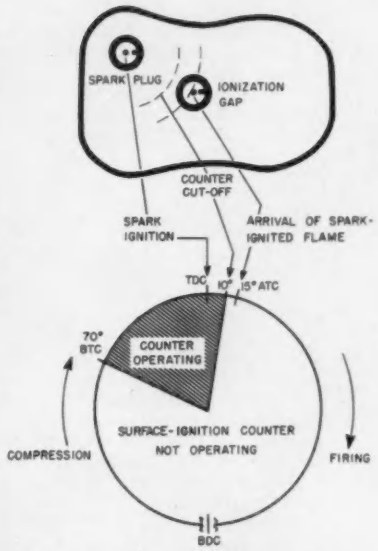


Fig. 1—The relative location of the spark plug and ionization gap and the portion of the engine cycle in which surface ignition is recorded in a single-cylinder L-head CFR engine is shown above.

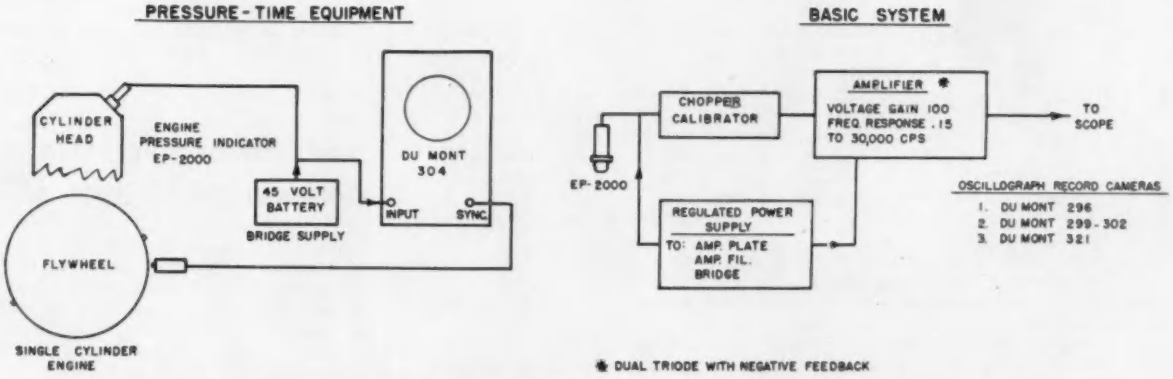


Fig. 2—A diagram of the instrumentation layout for a single-cylinder laboratory engine using the EP-2000 pickup is shown above. Details of the amplifiers are available on request to the CRC office.

Technical Committee Profiles

Allen

DEVELOPMENTS IN CURVED WINDSHIELD AND HEAT-ABSORBING GLASS led the Body Engineering Committee to review pertinent sections of the American Standards Association Glazing Code, reports **Chairman E. L. Allen.** Light transmission, heat absorption properties, strength and physical requirements, and area requisites for driver vision, are currently under study.

Spot and projection welding procedures will form a section of the Drafting Standards Manual. Material on simplified welding procedures and resistance welding is being developed for inclusion in the Manual.

Up-to-date seating developments are being funneled into a revision of the Automotive Seating Manual.

Nomenclature for body and sheet-metal parts will be worked on in the future.

The general subject of rearward vision is being studied by the new Automotive Mirror Subcommittee. Construction and placement of rearview mirrors for maximum driver vision are being determined.

Heinen

THE FUELS AND LUBRICANTS TECHNICAL COMMITTEE has consolidated several task groups into a single Subcommittee G on "Seal Materials and Related Products." The growing importance of the relationship between petroleum products, additives, and seals and hoses prompted this move, reports **C. H. Heinen,** chairman of the F & L Technical Committee.

To define multi-viscosity oils, the crankcase lubricants section of the Handbook is being studied. A tentative decision has been made to combine and augment the present General Information Report—"Multi-Viscosity Oils" and the Recommended Practice—"Crankcase Oil Classifications."

A distinctive feature of the F & L Technical Committee is its open forum, where off-the-cuff discussions take place on problems such as oxidation, stability of diesel and jet fuels, usage of chassis lubricants and modifications in gear oil terminology.

Kibbee

THE MEANING OF MANUFACTURERS' GROSS VEHICLE WEIGHT RATINGS for motor trucks is under scrutiny in a subcommittee of the Truck and Bus Technical Committee, reports **Chairman Lewis C. Kibbee.** Another subcommittee is bringing a report on truck full trailer safety chains up to date. Concurrently, the topic of full trailer couplers and pintle hooks is being discussed because of increased use of full trailers.

Semitrailer kingpins and tractor fifth-wheel design will be reviewed in a new joint group consisting of members appointed by both the Truck and Bus Technical Committee and the Transportation and Maintenance Technical Committee.

Work has been completed on an information report on truck noise measurement which appears in the 1957 Handbook. A report on riding comfort, a joint project with the Riding Comfort Research Committee, has been completed.

Kibbee, who is chief of the Automotive Engineering Section at the American Trucking Association, is also chairman of SAE's Washington, D. C., Section.

gap technique which only determines flame front arrival time.

The only apparent disadvantage is that detection of surface ignition on an oscilloscope is poor as well as the ability to count the number occurring.

While studying shifts of peak cylinder pressure in relation to crankshaft angle, various types of pickups may be used. Pressure-time signals are recorded on a Du Mont 322A dual-beam oscilloscope. A diagram of the layout for a single-cylinder laboratory engine using a Li EP-2000 pickup is shown in Fig. 2.

A layout for a multicylinder engine illustrates how spark-plug-equipped pressure pickups are used directly in the spark-plug hole. When one beam of the dual-beam oscilloscope is used to indicate flywheel position and output from Sperry vibration pickups, position of peak pressure and presence of heavy knock can be determined.

Rate-of-Pressure Rise Measurement Advantages

- Pickups are rugged, durable, and readily available in most CFR fuel rating engines.
- Detection of surface ignition on an oscilloscope is easy.
- Surface ignition severity may be measured.

The disadvantage is that a separate hole is usually required in cylinder head for pickup.

Rate-of-pressure rise instrumentation is established for single-cylinder engines by a photographic and counting technique. A photographic technique is used with multicylinder engines on the road and in the laboratory. Each technique requires a hole in the combustion chamber for the *dp-dt* pickup.

Pickups operating on the magnetostrictive principle, generating a voltage proportional to the rate-of-change of pressure are used. Proportionate voltage signal is then fed to an oscilloscope, counting circuit, or other instrumentation.

CRC report 304, "Combustion-Chamber Deposits—Instrumentation," contains 30 pp. including diagrams and photographs. It is available from SAE Special Publication Department. Price: $1 to members; $2 nonmembers.

Fuel Viscosity Function Accurate to 1% Says CRC

IF an accurate value of kinematic viscosity is obtained on an aviation fuel at 70 F, the viscosity at any other temperature from 0 to 100 F or higher can be computed with an accuracy at least as great as that usually obtained in industrial viscosity measurements. So states CRC report 294.

Viscosity data on 31 aviation fuels of 1943 production are recorded at three different temperatures. The temperature coefficient of viscosity function was

the same as that found for 56 commercial aviation fuels of 1940 and 1941 production.

Kinematic viscosity values of 15 AN-F-28 (100 octane number) and 16 AN-F-26 (91 octane number) fuels at temperatures of 0, 40, and 70 F are presented.

CRC 294, "Temperature Coefficient of Viscosity of Aviation Fuels," contains 19 pp. including three tables. It is available from SAE Special Publications Department. Price: $1 to members; $2 to nonmembers.

Safe Autogenous Ignition Temps For Fuel Pumps Studied

SAFE autogenous-ignition temperature values for fuel booster pumps in aircraft, explosion-proof test requirements, and dry-run tests for air turbine and hydraulic motor driven fuel pumps are under study in the Booster Pump Panel of Subcommittee A-16A, Fuel, Oil, Water, and Alcohol Pumps. Work will be carried out under the guidance of the Panel's new chairman, H. H. Borneman from Lear-Romec Division.

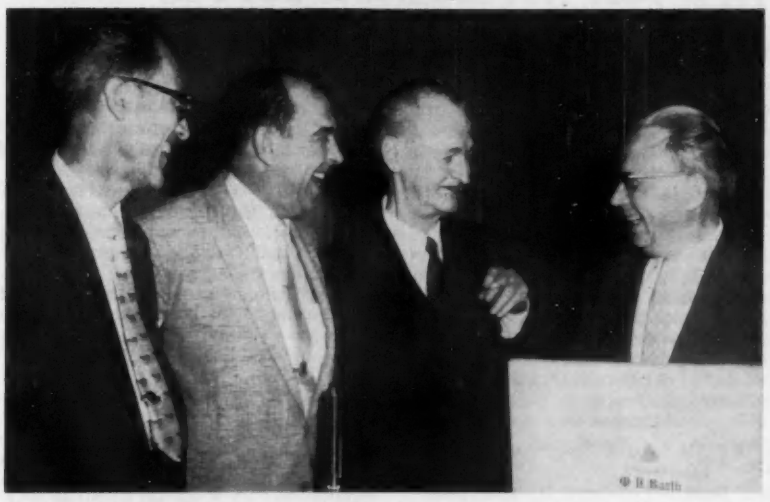
400 F is considered by the Panel to be a safe and conservative AIT value for the present. However, further information on AIT values for submerged fuel pumps is being gathered.

Existing designs of flame suppressing devices, such as slots, holes, vents, and flame traps incorporated in fuel booster pumps for the quenching or suppressing of flames under high ambient conditions, are being examined. A report made to the Panel on recent tests indicated that equipment designed to meet present explosion-proof test requirements at sea level, may not be adequately explosion-proofed at elevated temperatures. As a result of these observations, a recommendation was made to revise existing explosion-proof testing requirements to include testing under conditions experienced with pumps in fuel tanks. Two reasons support this recommendation: a-c booster pumps sometimes reach case temperatures of 400 F, and fuel tank ambient temperatures are often 160 F or higher.

A review of dry-run requirements for air turbine and hydraulic motor driven fuel booster pumps resulted in the panel's belief that current 5-hr dry run cycle requirements should be revised to include tests which are more compatible with the driving element. Overheating conditions as experienced on electric motor drives are not experienced during dry running of air turbines and hydraulic motors, and this is being taken into consideration.

The Panel recently finalized a proposal describing specific requirements which are considered of prime importance for preventing autoignition in fuel tanks.

W. L. Barth Honored By Society



W. L. Barth (third from left) is presented with a certificate in appreciation for 16 years of meritorious service as a member of the Screw Threads Committee. He was chairman for three years. With him are (left to right): R. F. Holmes, current Screw Threads Committee chairman; R. G. Cummings and Harold Fisher, both past chairmen.

AN embossed certificate was presented to W. L. Barth in appreciation of 16 years of meritorious service as a member and former chairman (from 1947 through 1949) of the SAE Screw Threads Committee. The presentation was made at a party honoring Barth on his retirement from General Motors. It was made in Detroit on June 13 by R. F. Holmes, current chairman of the Screw Threads Committee. Friends and associates from General Motors, the American Standards Association, and SAE were present.

For 29 of his 31-year association with General Motors, Barth has been engaged in screw thread standardization work. He was director of GM's Standards Section until recently when he began special assignment work on the staff of Charles A. Chayne, vice-president of engineering.

In addition to representing SAE on many of the American Standards Association's Sectional Committees, Barth has participated in the work of American Society of Mechanical Engineers and Automobile Standards Association groups. His contribution to the unification of American, British, and Canadian screw threads has been outstanding as evidenced by the fact that at one time Barth was a member simultaneously of 45 standardization groups.

25 New, 23 Revised AMSs Released By SAE

TWENTY-FIVE new Aeronautical Materials Specifications and twenty-three revised specifications are now available in loose-leaf form to supplement those previously issued. They are as follows:

- AMS 2262B — Tolerances — Nickel-Base, and Cobalt-Base Alloy Sheet, Strip, and Plate
- AMS 2420—Plating Aluminum For Solderability—(Zincate Process)
- AMS 3195—Silicone Rubber Sponge—Closed Cell—Medium
- AMS 3196—Silicone Rubber Sponge—Closed Cell—Firm
- AMS 3332—Silicone Rubber—Extreme Low Temperature Resistant (15–30)
- AMS 3357A—Silicone Rubber—Lubricating Oil and Compression Set Resistant (65–75)
- AMS 3648 — Polytrifluorochloroethylene Tubing—Unplasticized
- AMS 3649 — Polytrifluorochloroethylene Film—Plasticized
- AMS 3650A—Polytrifluorochloroethylene—Unplasticized
- AMS 3815—Braid, Flat, Nylon—Electrical Tying Synthetic Rubber Coated
- AMS 3840—Asbestos, Polytetrafluoroethylene Impregnated—Sintered
- AMS 4447—Magnesium Alloy Castings, Sand-3.3Th-2.1Zn-0.8Zr(HZ32A-T5)—Aged
- AMS 4500D—Copper Sheet and Strip—Soft Annealed
- AMS 4610G—Brass, Free Cutting—61.5Cu-3Pb-35.5Zn—Half Hard
- AMS 4674C — Nickel-Copper Alloy, Corrosion Resistant—67Ni-30Cu-0.04S—Free Machining
- AMS 4730C — Nickel-Copper Alloy Wire, Corrosion Resistant—67Ni-30Cu—Annealed
- AMS 4908A—Titanium Alloy Sheet, 8Mn, Annealed—110,000 psi Yield
- AMS 4911—Titanium Alloy Sheet, 6Al

Continued on page 136.

New Test Requirements Set For Hydraulic Components In Aircraft

RELIABILITY is an element of prime importance in establishing test requirements for aircraft hydraulic components expected to function in the – 65 to 400 F (Type III) temperature range.

The test procedures set up by a panel of SAE's Aircraft Hydraulic and Pneumatic Equipment Committee (A-6) are presented in two phases. Phase I outlines preliminary screening tests not related to any specific applciation of the component. Phase I requirements must be met before Phase II tests are attempted. Phase II consists of specific requirements and design considerations for components.

Phase I—Preliminary Screening Tests

(1) Seven-day soak at 400 F followed by proof test at temperature.

(2) Following stabilization at – 65 F, perform operation and leakage check to insure that the component will operate. Fluid shall then be rapidly warmed to 400 F while continuously cycling component. *Note:* Full performance requirements are not required below – 20 F.

(3) Stabilize fluid and ambient at 400 F for one hour with component under rated pressure.

(4) Operationally cycle component for one hour with fluid at 400 F and ambient no less than 375 F.

(5) While continuously cycling, cool component rapidly to room temperature (70–110 F) in approximately one hour. Conduct leakage check at room temperature.

(6) While continuously cycling, warm fluid to 400 F as rapidly as possible.

(7) Repeat steps (4), (5), and (6) four times.

(8) Every fifth cycle repeat steps (3), (4), (5), and (6). In step (5), instead of cooling to room temperature, cool to – 20 F. Check for leakage after stabilization at – 20 F. Cool further to – 65 F for an external leakage check after stabilization.

(9) Repeat steps (7) and (8) until failure.

Temperature Conditions—400 F means no cooler than 400 F. Room temperature is 70 to 110 F. – 20 and – 65 F mean no warmer than – 20 and – 65 F.

Phase II Specific Design and Test Considerations

Specific requirements for components should be based on expected use of component in the aircraft. Proper values should be specified for the flight profile. It is desirable to simulate operational effects such as thermal cycling, vibration, acceleration, shock, and other factors as closely as possible to actual flight conditions.

The following check list of design considerations is intended as a guide for the formulation of specific test requirements.

- Material degradation and creep.
- Thermal effects on materials conducive to differential expansion.
- Corrosion protective finishes should be carefully studied for adverse effects due to environmental conditions. Cadmium and zinc plating shall not be used.
- Heat transfer characteristics of the component.
- Chemical and mechanical properties of the fluid, plus compatibility with other materials in the system.

Specific Test Considerations

Temperature—Test under actual flight conditions.

Pressure—Pressure requirements should include impulse, surge, and rate-of-pressure rise in addition to normal system pressure variations.

Endurance—Total cycles and/or time should be representative of a typical flight profile.

Frequency and Rate—The frequency and rate should be compatible with response requirements.

Loading—Actual aircraft loads with variations of magnitude should be used during endurance cycling. However, acceleration, shock, and aerodynamic loadings must also be included where such loadings affect performance.

Shock and Vibration—Amplitude and frequency should simulate airplane vibrational environment.

Acceleration—Steady-state acceleration shall be a factor of design and performance.

In setting up Type III requirements, the High-Temperature Hydraulic Systems Panel was supplementing previous test requirements set up for the – 65 to 275 F (Type II) temperature range.

The new procedures were drafted specifically for Type III components and are considered minimum. They may be adjusted upward as required. Full operating performance at – 65 F was considered unnecessary since systems warm up rapidly. The Panel was also cognizant of the penalties on design which would be imposed if full performance were required below – 20 F.

No specific hydraulic fluids were recommended.

Those who attended the three-day panel meeting where the new requirements were drafted are: Panel Chairman F. C. Mittell, North American Aviation; J. H. Ballantoni, Chance Vought Aircraft; John Bloom (Representing K. W. Dubois) of Douglas Aircraft Co.; Howard Field, Jr., Convair;

Hydrocarbon Combustion Character Studied by CRC

AUTOIGNITION characteristics of several pure hydrocarbons injected into a constant-volume combination bomb are reported in CRC report 297. The effect of pressure, temperature, and pure hydrocarbon structure in the C_6–C_{10} range on ignition delay are covered. The study was prompted by the need for additional information to reliably relate behavior of fuel characteristics and pressure-temperature conditions under which autoignition occurs.

Normal paraffins, alpha olefins, five monocyclic naphthenes, a normal and a branched dodecylbenzene, and the highly branched isomers, isooctane, and triptane are the hydrocarbons included. Data on the secondary diesel reference fuels is presented for purposes of comparison.

Ignition delay measurements were made at bomb pressures of 250 and 650 psig for each of eight temperatures covering the range 500 F to 1390 F. Data have been summarized to show the effect of molecular structure.

Test data show that the secondary diesel reference fuels T-13 and U-6 have markedly different temperature sensitivities. As a result, the ignition delay of the low cetane fuel becomes less than that of the high cetane fuel at low test temperatures. Data on pure hydrocarbons show that different types have temperature sensitivities sufficiently different to explain this phenomenon.

Increase of bomb pressure from 250 to 650 psi with high test temperatures resulted in lowered ignition delay for all fuels tested. However, with low test temperatures, most fuels gave increased delay with increased pressure when the quantity of fuel injected was the same for both conditions of test. Under these same low temperature test conditions, ignition delay was lowered by injecting more fuel and, therefore, increasing fuel-air ratio.

The branched isomers, isooctane and triptane, gave unusual ignition behavior. As temperature was increased, ignition delay first decreased, then increased, and again decreased. It is suggested that this reversal of the temperature-delay trend may result from high-temperature destruction or inhibition of ignition promoting intermediate reaction products.

CRC 297, "Progress Report - Combustion Characteristics-Ignition Delay Bomb - January 1953 Through June 1954," contains 29 pp. including tables and graphs. It is available from SAE Special Publications Department. Price: $1 to members; $2 nonmembers.

George Keller, Autonetics; B. L. Mettee, Bureau of Aeronautics; Ralph Middleton, Lockheed Aircraft; Phil Musa, Grumman Aircraft Engineering; G. C. Newell, Boeing Airplane Co.; Fred Pollard, Republic Aviation; P. F. Rossi, North American Aviation; J. R. Snyder, McDonnell Aircraft; and Frank Straus, Wright Air Development Center.

The High-Temperature Hydraulic System Panel reports to the Aircraft Hydraulic and Pneumatic Equipment Committee (A-6) of which Baboo Ram "Bob" Teree is chairman. Mr. Teree is vice-president in charge of engineering and manufacturing at Greer Hydraulics.

CRC Studies Evaporation Temp. of Aviation Fuels

AN analysis of data on temperature drop during the partial evaporation of aviation fuels resulted in two conclusions: (1) an approximate relationship between fuel characteristics and temperature drop, and (2) an accurate relationship covering the effect of initial temperature, requiring only an observation at one initial temperature, such as 100 F.

The experimental data used in this analysis covered nine diverse aviation fuels each tested at several initial fuel temperatures and at various pressure reductions corresponding to altitudes up to about 50,000 ft.

Recommendation is made for further study of additional fuels to secure a more accurate relationship, and to enable a more comprehensive comparison with available pure hydrocarbon data.

CRC 295, "Thermal Properties of Aviation Fuels in Relation to Fuel Evaporation Losses at Altitude", contains 21 pages including graphs and tables. It is available from SAE Special Publications Department. Price: $1 to members; $2 to nonmembers.

Balancing of Aircraft Turbine Rotor Components Tackled by New SAE Group

DIMENSIONAL and performance standards for balancing machinery to accommodate aircraft turbine engine rotor components will be studied by the Aircraft Tooling Subcommittee's new Balancing Subgroup. Their objective is to enable balancing of any major turbojet and turboprop engine parts on a balancing machine constructed according to the cooperative findings of the group.

The Balancing Subgroup's objectives include the following:

- Establishment of physical dimensions of balancing machines so that rotors from engines now in use and planned for the immediate future will fit the machines using sample adapters supplied by the engine companies.
- Development of minimum performance standards for balancing machines which insure rotor balance in accordance with design specifications.
- Cooperate on the development of nomenclature for balancing terms, if necessary.

Two-Plane Dynamic Balancing Machine First Project

Dimensioning and performance of a balance machine facilitating two-plane corrections of complete rotors will be the Subgroup's first undertaking. Three weight classes of rotors have already been established. They will be for rotors up to 300 lb, 1000 lb, and 3000 lb.

Since balancing machines commonly have two rotor supports, it was decided that each support should be capable of carrying two-thirds of the weight class load.

Tentatively established were maximum swing diameters of rotors, journal diameter of balancing machine supports, maximum length between rotor support, and speed ranges for belt-driven rotors for each weight class.

Performance characteristics of balancing machines were discussed from the standpoint of a standard master rotor and translating unbalance in a rotor in terms of the force at the pickup of a balancing machine. A standard master rotor is favored since it does not involve detailed mathematical calculations on the part of production or overhaul shops.

Information is being sought from industry on the following topics:

- Envelope dimensions of any rotors (mounted inboard or outboard) currently in use with detailed interference dimensions for each rotor.
- Envelope dimensions of balancing machine supports within swing diameter.
- For driving the rotor by end adapters, a flange with a standard pilot diameter and bolt circle as a means of attachment between the rotor and the balancing machine is favored. Information is being sought on flange hole and pilot diameters, and pilot depth for each weight class balancing machine.

Isolation of planes and angle of balance in two-plane balancing systems for full rotors is slated for discussion at the next meeting. In addition, work will be directed toward developing single-plane correction and static-balancing machinery.

Harold L. Seekins of General Electric Co. has accepted the chairmanship of the Balancing Subgroup, which will meet again on September 10 in Dayton, Ohio, at the Biltmore Hotel.

Balancing Subgroup Holds First Meeting at Wings Club in Manhattan

Two-plane dynamic balancing of turbine rotor components was discussed at the first meeting of the Aircraft Tooling Subcommittee's new Balancing Subgroup. Shown above (l. to r.): W. G. Kuensch, J. P. Lange, S. B. Haney, G. E. Leighton, R. T. Buscarello, R. C. Springer, W. I. Senger, David Kravitz, J. P. Lannen, E. J. Harmon, B. A. Beaton, Acting Chairman L. B. Hansen, and C. W. Phelps. The Subgroup's next meeting will be held in Dayton, Ohio, on September 10.

About SAE

Burnett

Henry

Ference

Chayne

Smith

Daniels

Livingstone

Wickenden

DAVID S. BURNETT has been elected vice-president in charge of the Detroit Steel Products Division of Fenestra Inc. He has also been appointed to the newly-created position of general manager of the division. Burnett joined the company in 1951 after serving on the sales staff of the Eaton Mfg. Co.

LEVI L. HENRY, dean of the College of Engineering, Detroit Institute of Technology, has been awarded an honorary degree of Master of Science from the Detroit Institute.

Dean Henry has been a member of SAE since 1946 and serves as faculty advisor to the SAE student branch at D.I.T. He has acted in this capacity since the branch was chartered in 1945.

ROBERT G. GREEN has been awarded an alumni citation from the Detroit Institute of Technology. Green serves as sales engineer for the Eaton Mfg. Co.

DR. MICHAEL FERENCE, JR. has been named director of the Scientific Laboratory, Ford Motor Co. Ference joined Ford in 1953 as chief scientist of the Scientific Laboratory, and was made associate director of the laboratory in 1955.

Prior to joining Ford, he was chief scientist and technical director of the Evans Laboratory in Belmar, N. J. Ference also taught for 10 years at the University of Chicago and organized the school's laboratories for hydrodynamics and upper atmosphere research. He is the co-author of a textbook on Physics and has had numerous technical papers published.

CHARLES A. CHAYNE, General Motors Corp. vice-president in charge of engineering, has been elected to a 5 year term on the governing body of the Massachusetts Institute of Technology.

A graduate and former instructor at MIT, Chayne was selected one of three alumni association representatives on the MIT corporation. He has been a member of MIT's mechanical engineering visiting committee since 1951.

Chayne was graduated from MIT in 1919 and a year later joined the faculty as an instructor in mechanical engineering until 1926. He joined GM's Buick Division in 1930 and became chief engineer of Buick in 1936. He has been GMC vice-president in charge of engineering since 1951.

JACK P. PEDERSEN, formerly sales manager, Warner Division, Detroit Harvester Co., has been appointed director of the newly-formed Denison Research Foundation.

The Foundation is a not-for-profit Ohio corporation that will serve industry and the U. S. Government by providing research talents and facilities for conducting a wide variety of research. Initial emphasis will be on projects in the electronic, mechanical, metallurgical, ceramic, and management fields.

CHARLES P. ROBERTS, professor of internal combustion engineering, Ohio State University, will serve on the Supervising Board of Consultants for the Denison Research Foundation.

HAROLD V. NUTT has been named to the newly-created post of technical director of the Engineering Experiment Station, Annapolis, Md. Nutt will be the principal civilian administrator at the Station, in charge of its scientific program. Formerly he was superintendent, Internal Combustion Engineering Laboratory, Department of the Navy, at the Annapolis Experiment Station.

E. B. FALK has been appointed manager, advertising and sales promotion, of the Twin Disc Clutch Co., Racine, Wis. Falk has been with Twin Disc since 1946, serving as sales engineer, application engineer, installation engineer and administrative assistant, general sales department.

DONALD M. McDOWELL has been named manager of engineering for the Le Roi Division, Westinghouse Air Brake Co., Milwaukee. Formerly he was acting manager of the division's engineering department.

STANLEY B. SMITH, JR. has been appointed sales manager of aircraft engine equipment at the Bendix Products Division of Bendix Aviation Corp. Previously he was chief engineer, aircraft carburetor, gas turbine controls section II, Bendix Products Division.

ROGER L. DANIELS has been named to the post of chief engineer of the Formsprag Co., Van Dyke, Mich. Prior to his new post, Daniels was project engineer for the company.

HAL A. LIVINGSTONE has joined Holloman Air Force Base, N. Mex. as chief liaison, projects section, in connection with the high speed test track. Prior to his re-location, Livingstone was with the Wright-Patterson Air Force Base, Ohio, working with Wright Air Development Center (Engineering Standards).

THOMAS H. WICKENDEN has been awarded an honorary degree of Doctor of Science from Denison University. The degree was conferred in recognition of Wickenden's "substantial contributions in the field of metallurgy."

In 1954 Wickenden retired as vice-president of the International Nickel Co., Inc., and manager of its Development and Research Division.

J. D. SEWELL has been appointed forward planning and production analysis manager for the manufacturing engineering office, Ford Motor Co.

Members

Pedersen

Nutt

Falk

McDowell

Sewell

Edwards

Misch

Rainey

Sewell joined Ford in 1949 and most recently was on the staff of the executive vice-president—Car and Truck Divisions.

CRAIG H. EDWARDS has joined the Weatherhead Co. as west coast sales manager for aircraft and ordnance. For the past four years, Edwards has been manager of west coast sales and service for the New York Airbrake Co.

HERBERT L. MISCH has been named assistant chief engineer of the product engineering office of Mercury Division, Ford Motor Co. Concurrent with his appointment, Misch also was made a member of the management, merchandising, and product committees of the division. Prior to joining Mercury, he was director of advanced product planning, Cadillac Motor Car Division, General Motors Corp.

JAMES RAINEY is now district sales manager for the South Central area, the Yale & Towne Mfg. Co. Most recently Rainey managed an industrial lift sales and service center in Memphis. His new headquarters will be in Chicago.

HERBERT C. KIESLING has joined the Kollsman Instrument Corp. as contract administrator in the sales engineering department. Prior to his new post, Kiesling was superintendent of instrument overhaul for the Durham Aircraft Service, Inc., Woodside, N. J.

C. G. A. ROSEN, SAE president in 1955, delivered the opening address at a "problem solving seminar" of the Food and Machinery and Chemical Corp. The three-day meeting was attended by members of the engineering management group of the company's machinery divisions and members of the central engineering department. Rosen serves as consulting engineer to the president of Caterpillar Tractor Co., and consultant to Richfield Oil Co. and the Union Pacific Railroad.

J. H. CARMICHAEL, president of Capital Airlines and vice-president of the United States Chamber of Commerce, delivered a speech at a luncheon meeting of the Members Council of the New Orleans Chamber of Commerce, June 20. Carmichael called upon businessmen to expand foreign trade as a vital asset to our national security and asserted that industry leaders should not fear rising foreign import rate which he termed a necessary aid to our country's progress.

ALVIN M. YOCUM, field engineer, Raybestos-Manhattan, Inc., has retired from the company. Yocum has represented R/M for almost 30 years.

WILLIAM B. PAINE has been elected executive vice-president of Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio. Formerly, Paine was general manager of the Kansas City Division of Bendix Aviation Corp.

Paine joined Bendix Aviation at South Bend, Ind. in 1931, serving as laboratory engineer and later as chief engineer. He has served as director of production of aircraft armament at South Bend and was general manager of a Bendix Wartime Division at Owosso, Mich. He served subsequently on the staff of the president of the corporation and general manager of the Skinner Purifiers Division at Detroit. In 1948 he was named general manager of the Kansas City Division.

Paine will continue to serve as a director of Bendix-Westinghouse and will also continue to be available as a consultant to the Atomic Energy Commission.

I. F. RICHARDSON has been named to succeed Paine as general manager at the Kansas City Division of Bendix Aviation Corp. Since 1953 he has been serving as assistant general manager for the division.

Richardson joined Bendix in 1936 at South Bend as an aircraft equipment engineer. He became assistant manager for aircraft equipment sales and service in 1946 and manager in 1951.

ELDRED E. EVANS has been made assistant general manager of the Kansas City Division of Bendix Aviation, succeeding Richardson. Previously he served as director of the production management staff and quality control manager for the division.

He has been associated with the division for eight years and has also served as assistant engineer of Bendix-Westinghouse.

GEORGE A. PAGE, JR., vice-president, research and engineering of Aeronca Mfg. Corp., has retired from active duty with the company. He will continue to serve as a consultant for the company.

Prior to joining Aeronca in 1951, Page spent 34 years with Curtiss-Wright Corp. He started as a draftsman for the company, was made chief engineer for their St. Louis, Mo. plant, and subsequently director of all Curtiss-Wright Airplane Division engineering.

During Page's 45 years of aircraft experience, he has been accredited with designing, developing, producing and flying over 90 basic types of aircraft.

ROBERT W. SUTTON, formerly assistant chief engineer in carburetor engineering, Eclipse Machine Division, Bendix Aviation Corp., has been appointed assistant chief engineer of the electronics engineering department, Bendix. Sutton is one of the engineers chiefly responsible for the development of the Electrojector, the electronic automotive fuel injector system introduced by Bendix.

Zeder Heads Science Fair

SAE PAST-PRESIDENT JAMES C. ZEDER, vice-president, engineering—special advisor to president, Chrysler Corp., will serve as chairman of the first Science Fair to be held in metropolitan Detroit. The fair will be staged at the Michigan State Fairgrounds, May 1–4, 1958.

Sponsored jointly by the Engineering Society of Detroit and *The Detroit News*, the Science fair will display all types of biological and physical science principles. The exhibits will be developed and built by intermediate and high school students from surrounding counties.

Other SAE members serving with Zeder on the Fair Committee will be **WILLIAM H. GRAVES,** newly-installed president of the Engineering Society of Detroit and professor of Automotive Engineering and director of the Automotive Engineering Laboratory at the University of Michigan; **MALCOLM P. FERGUSON,** president of Bendix Aviation Corp.; **DR. LAWRENCE R. HAFSTAD,** vice-president of research for General Motors Corp.; **ANDREW A. KUCHER,** vice-president of engineering and research for Ford Motor Co.; and **GEORGE ROMNEY,** president of American Motors Corp.

GARLAND O. GODWIN has been named design engineer, Convair Division, General Dynamics Corp., San Diego, Calif. Formerly he was associate engineer for the company.

FRED G. MOSER has been made manager of original equipment sales of Johnson Bronze Co., New Castle, Pa. Formerly Moser served as director of product engineering.

W. R. TOEPLITZ, president of the Bound Brook Oil-Less Bearing Co., has been named chairman of the technical committee of the newly formed Powder Metallurgy Parts Manufacturers Association.

M. T. VICTOR has been made chairman of the statistics committee of PMPMA. Victor is president of the International Powder Metallurgy Corp.

SMITH BOLTON, president of the United States Graphite Co., has been named chairman of the budget committee of PMPMA.

GEORGE H. LANCASTER has joined the Chek-Chart Corp. of Chicago. Prior to his new position, he was chief engineer, fuels and lubricants, industrial power engineering department, International Harvester Co.

A. P. JAMBULINGAM has been made professor of Mechanical Engineering and head of the Department of Mechanical Engineering, College of Engineering, Guindy, Madras, South India, Indian Union. Previously he was assistant professor of Mechanical Engineering at the University.

J. ROBERT LAKIN, previously assistant general sales manager, Delco Products, General Motors Corp., has been named general sales manager of Moraine Products Division of the company.

GEORGE K. ISAACS has joined the Aeronautical Division of Minneapolis-Honeywell Regulator Co. as development engineer. Formerly Isaacs was development engineer, Magneto Division, Fairbanks Morse & Co., Beloit, Wis.

ALBERT M. ANKROM has been named sales consultant, Raybestos Division, Raybestos-Manhattan Inc., Stratford, Conn. Prior to his new position, Ankrom was sales consultant for the Armstrong Cork Co., Lancaster, Pa.

SHERMAN L. BREMER is now sales representative, Truck and Coach Division, General Motors Corp. Previously he was product representative, truck technical service, GM Truck and Coach Division, GMC.

WILSON P. GREEN has been made technical director, Product Planning Division, Parker Pen Co. Before joining Parker, Green was manager of the Heat-Power Division of the Armour Research Foundation of Chicago.

RAYMOND C. JOHNSON has been made resident engineer of the Trenton Engine Plant of Chrysler Corp. Formerly he was engine engineer, Dodge Division, Chrysler.

GILBERT F. BRODERS is now retail branch manager, General Motors Corp. Truck and Coach Division, GMC. Formerly he was fleet representative for the GMC Truck and Coach Division.

GUTHRIE C. KIMBROUGH, formerly sales engineer, the Pure Oil Co., has been named district automotive and industrial sales engineer for the company.

REBECCA HALL SPARLING, staff consultant, Convair Division, General Dynamics Corp., has been selected one of the "Women of the Year" by the Quotarian, official publication of the Quota Club International, Inc. The Quota Club is a service organization for executive and professional women.

Jolley

Petersen

MALCOLM JOLLEY has been elected president of Russell Industries, Canadian Acme Screw & Gear Ltd., and York Gears Ltd. Previously Jolley served as vice-president and general manager of Canadian Acme Screw & Gear. He has also served as a director of Russell Industries and its subsidiaries.

Jolley, a member of SAE since 1945, served as 1950–1951 chairman of the Canadian Section. He has also served as Councilor in 1955–1956.

NEIL P. PETERSEN has retired as president of the Canadian Acme Screw & Gear Ltd. Petersen took an active part in the formation of the company in 1924, and has been the president since 1940. He has also retired as an executive officer of other subsidiaries of Russell Industries Ltd. and will continue as a director of Russell Industries and its subsidiaries.

Petersen has been a member of SAE since 1929 and served as 1935–1936 chairman of the SAE Canadian Section.

WILLIAM J. VACHOUT, vice-president and general manager, Molded Materials Division, Carlisle Corp., has been elected president of Friction Materials Standards Institute, Inc.

GEORGE S. LAMSON, vice-president, Replacement Division, Thermoid Co., has been elected vice-president of the Institute.

M. J. MARKOWSKI has reassumed full time activity with the Mark-Shaw Corp. of Cleveland. In addition to his engineering work, he is directing the formation of a new company to produce die castings.

WALTER B. HOUGH, JR., has joined the Missile Systems Division, Lockheed Aircraft Corp., as construction engineer. Formerly he was mechanical engineer with the atomic fuel handling and atomic power systems, Atomic Power Division, Westinghouse Electric Corp.

VICTOR HENRY F. HOPKINS has joined the Diesel Engine Division, English Electric Co., Ltd., Rugby, England. Formerly he was group chief engineer for Marshall Sons & Co., Ltd. of Gainesborough and John Fowler & Co., Ltd. of Leed, England.

H. B. SPORE has become affiliated with the Martin Co., Orlando, Fla. Previously Spore was section supervisor, Gyroscopic Components, Sperry Farragut Co. Division, Sperry Rand Corp.

EMIL P. GOHN, formerly assistant manager, Automotive Division, Atlantic Refining Co., has joined the Marine Operating Division of the company.

An SAE member since 1937, Gohn served in 1945 as vice-president representing Transportation and Maintenance Engineering.

SAE Father and Son team enjoying the Summer Meeting in Atlantic City is CARL W. GEORGI (left), vice-president, Quaker State Oil Refining Corp. and ROGER GEORGI, senior at the University of Buffalo.

The elder Georgi is responsible for recent joint action of the SAE Engine and Transmission Committees and the Petroleum Institute to standardize crankcase and transmission dipsticks.

He also is the author, in addition to many SAE technical papers, of a book entitled "Motor Oils and Engine Lubrication."

JOHN ROY McLEAN, formerly manager of replacement sales for Auto-Lite Batteries of Canada, Ltd. in Toronto, has been made sales manager for the company in Calgary, Alberta.

WALTER C. SHAW, formerly preliminary design engineer, has been named chief of preliminary design, Hamilton Standard Division, United Aircraft Corp.

H. O. MATHEWS (right), general manager, transportation and distribution, Armour & Co., receives the Annual Tribute Award of the Automotive Council of Los Angeles from COL. L. L. BEARDSLEE, president of the Council.

Mathews was honored for outstanding national contributions to motor transportation and trucking industry.

BERNARD W. ST. CLAIR has joined Westinghouse Electric Corp. as mechanical engineer. St. Clair is working at the Naval Reactor Testing Station, atomic energy. Previously he was district representative for the National Carbon Co.

EARL F. HUBACKER, JR. has joined the Chemstrand Corp. of Pensacola, Fla. as mechanical engineer, process assistance. Formerly he was research engineer with McDonnell Aircraft Corp. of St. Louis, Mo.

WILLIAM K. NORWICK has been appointed senior engineer-in-charge, product engineering, engineering shops, Fisher Body Division, General Motors Corp. Formerly he was executive assistant to the chief engineer of the Fisher Body Division.

Norwick has been a member of SAE since 1942, and now serves as SAE vice-chairman for Body Activity, Detroit Section.

WILLIAM B. PASHKOW has been named director of fire apparatus and special equipment engineering for the Sidney, Ohio Division of Mack Trucks, Inc. Previously he had served in the engineering department at the Allentown, Pa. factory of Mack Trucks. Pashkow has served with the company since 1955.

B. H. WEIL has been named chief editor, Technical Information Division, Esso Research and Engineering Co. Formerly he was manager of information services, research laboratories, Ethyl Corp.

W. S. James

SAE PAST PRESIDENT W. S. JAMES was guest of honor at ASTM's D-2 Annual Dinner at Atlantic City's Hotel Traymore on June 18. Other SAE presidents similarly honored in years gone by were **DR. H. C. DICKINSON** in 1946 and **DR. C. G. A. ROSEN** in 1953. (D-2 is ASTM's Committee on Petroleum Products and Lubricants.) . . . SAE members who participated in the speaking program were **W. T. GUNN**, American Petroleum Institute, and SAE Past-President **DR. D. P. BARNARD.**

DUANE R. PROSSER has joined the Bettis Plant, Atomic Power Research Laboratory which Westinghouse Electric Corp. operates in Pittsburgh for the Atomic Energy Commission. He will do engineering and development work on a nuclear powered surface vessel prototype.

Previously Prosser was mechanical engineer, Department of the Navy, Bureau of Aeronautics.

PAUL V. FARAGHER was honored during the 60th annual meeting of the American Society for Testing Materials. Faragher was cited for long-time respected leadership and significant contributions to the activities of the ASTM. He is retired from the Metallurgical Division, Aluminum Co. of America, Pittsburgh.

Chrysler Corp. has received one of the three annual awards presented by the Industrial Designers' Institute. **VIRGIL M. EXNER**, director of styling, Engineering Division, Chrysler Corp., was named in the presentation as well as two other SAE members, **CLIFFORD C. VOSS** and **CARL REYNOLDS.**

JOHN B. BURNELL has been appointed to the newly-created position of assistant chief engineer in charge of advanced design for the Rochester Products Division, General Motors Corp.

Burnell joined GM in 1941, serving in the Chevrolet Division and on the GM Engineering Staff. Prior to his new post, he was assistant staff engineer for passenger car engines with Chevrolet.

GRIFFITH MAY has joined the McNickers Co., Cambridge, Mass. as general manager. Formerly he was chief engineer, Screen Products, Inc., Caldwell, N. J.

VIRGIL J. PALUB is now manufacturing engineer, the Martin Co., Denver, Colo. Previously he was manufacturing engineer, Missile Systems Division, Lockheed Aircraft Corp.

ROBERT T. CURCURU has joined the Jim Robbins Co. as general manager, Research and Design Division. Formerly he was managing engineer, Advanced Truck Development, Chrysler Corp.

W. S. WOLFE has been appointed director of domestic production, Goodyear Tire & Rubber Co. Previously Wolfe was factory manager, Domestic Plants, for the company.

H. H. CLARK has been appointed assistant general manager of the Spring Division, Eaton Mfg. Co.

Clark joined the Spring Division in 1931 as assistant chief engineer, and subsequently became manager of the coil spring department of the division.

R. G. GREEN has been made sales manager of the leaf spring department, Spring Division of Eaton. Green has been with the company since 1948 in engineering and sales capacities.

R. D. MORRISON is now sales manager of the coil spring department, Spring Division of Eaton. Formerly he was serving in product and sales engineering departments. He joined Eaton in 1940.

HAROLD F. PIERCE has joined the H. A. King Co., Detroit, as chief engineer, design, research and development of functional mechanical rubber units. Previously he was senior project engineer, engine components, with the Chevrolet Division of General Motors Corp.

Peirce's activities in the automotive field include periods with the Chrysler Corp., United States Rubber Co., Ford Motor Co., and General Motors Corp.

FRED A. WINZER, JR. has been named vice-president—sales for the Waldorf Instrument Co., division of F. C. Huyck & Sons. Previously he was sales manager, Aviation and Ordnance, Weatherhead Co.

GEORGE E. HERMAN, formerly sales engineer, Aluminum Co. of America, has been made manager of commercial automotive sales for the company. Formerly he was located in Detroit, his new offices will be in Pittsburgh.

Obituaries

KARL BEAVER . . . (M'37) . . . resident engineer, research laboratories, Ethyl Corp. . . . joined the company in 1930 . . . died in March . . . born 1908.

E. ROGER BURLEY . . . (M'20) . . . retired (1956) manager, Available Truck Co., Chicago . . . graduate Armour Institute of Technology . . . has died . . . born 1890. . . .

RALPH F. BURNS . . . (M'52) . . . manager, metal sales, western district, New Jersey Zinc Co. . . . joined the company in 1928 . . . died March 29 . . . born 1898. . . .

MAX L. HOWARD . . . (J'56) . . . experimental engineer, Studebaker-Packard Corp. . . . graduate West Point Military Academy, 1952 . . . died March 16 . . . born 1928. . . .

JOHN E. MATHEWS . . . (J'54) . . . flight test engineer, Atlas ICBM, Convair Division, Astronautics Division, General Dynamics Corp. . . . graduate Case Institute of Technology, 1951 . . . died March 7 . . . born 1928. . . .

ARTHUR P. McCABE . . . (M'54) . . . chief aerodynamicist, Department of Army, White Sands Proving Ground, technical staff, Ordnance Corps . . . graduate Massachusetts Institute of Technology, 1941 . . . died June 7 . . . born 1918. . . .

JOHN B. MEZEY . . . (A'37) . . . Mezey Motors Inc. . . . started own business in 1915 . . . died May 11 . . . born 1884 in Hungary. . . .

ARTHUR M. REIBITZ . . . (M'48) . . . sales engineer, Detroit representative, Rockford Clutch Division, Borg Warner Corp. . . . joined company in 1945 . . . died April 7 . . . born 1906. . . .

FRED L. SAGE . . . (M'24) . . . retired director of engineering, Truck Division, Chrysler Corp. . . . died June 11 . . . born 1888 in South Dakota. . . .

EVERETTE M. SCHULTHEIS . . . (M'16) . . . 1944 SAE vice-president representing Truck and Bus Engineering . . . consultant to the president of Clark Equipment Co. . . . former vice-president, Clark Equipment Co. . . . died May 8 . . . born 1893. . . .

HAROLD M. STUELAND . . . (M'50) . . . project engineer, John Deere Spreader Works . . . joined the company in 1939 . . . died June 10 . . . born 1903 . . . holder of numerous patents.

ARTHUR P. WARNER . . . (M'24) . . . president, Warner Patterson Co. . . . former president and general manager, Warner Instrument Co., Warner Trailer Co., Beloit, Wis. . . . died March 22 . . . born 1870. . . .

SECTIONS

August 1957

Television Cameras Catch Pittsburgh Section In Action

THE television audience will soon tune in SAE in action via metropolitan Pittsburgh's WQED. SAE Pittsburgh Section has instituted the TV medium to win friends and influence people for the Section.

WQED Channel 13, is a non-commercial, educational station whose coverage includes metropolitan Pittsburgh, western Pennsylvania's industrial district, nearby Ohio and West Virginia. The Pittsburgh Section SAE Television Committee has secured free time for 13 weekly one half-hour programs, starting mid-September and ending in December.

SAE Past-President R. J. S. Pigott will serve as regular host for the series which will be entitled "Your Automobile and You." Each week a Pittsburgh Section member will appear as guest speaker. Students from the SAE Student Branches at University of Pittsburgh and Carnegie Institute of Technology will be called upon to act as assistants.

Procedure for the half-hour will include an introduction by Pigott, 20–25 minute talk by the guest speaker, and a concluding 3-minute summary by the host. Arrangements have been made for actual demonstrations, displays, and equipment in the TV studio for use by the speakers.

The tentative program list includes development of the early car as the introductory program, followed by such topics as "Electrical System," "Brakes," "Springs and Shock Absorbers," "Engines," "Fuels," "Lubricants," "Carburetors and Fuel Injection," "Tires," "Transmission and Axles," "Handling," "Appearance," "Tires," and "Maintenance."

SAE Section Meetings

CHICAGO:

September 6 . . . Olympia Field Country Club. Dinner 6:00 p.m. Special Features: 1957 Annual "Playday"; Golf, Dinner, Prizes, Entertainment.

SOUTH BEND DIVISION:
September 16.

From Section Cameras

Five men gather at the Central Illinois Section May meeting to discuss NASCAR Racing and automobile insurance. Appearing left to right are John Holman, main speaker, Peter De Paolo Engineering Co., and John C. Cox, speaker, Purolator Products Inc., the two experts on NASCAR Racing; W. Miller Owen, Caterpillar Tractor Co.; N. A. Loar, State Farm Insurance Co., coffee speaker on automotive insurance problems; and Roy E. Mayo, Caterpillar Tractor Co.

KUCHER Predicts "Golden Years of Engineering

MORE than 2000 SAE members, at the Detroit Section's final 1956–57 meeting, heard Ford Motor Co.'s Andrew A. Kucher describe the progress which lies ahead in the coming era of engineering progress. The meeting was held May 24 at Ford's new Romeo Proving Ground—beginning with a narrated tour of the area. Test facilities the engineers saw included a 5-mile high-speed track, a 2.5-mile straightaway, 18 miles of endurance roads, a watercourse, and dust roads. Exhibits in test garages and the Operations Building were made available to the group, demonstrating the proving ground working tools, instrumentation, and products.

Following the tour, a dinner and a technical session were held in the Operations Building of the proving ground.

Main speaker of the evening, Kucher, Ford Motor Co. vice-president of engineering and research, discussed current areas of research and predicted where this research will lead, as well as its impact on the automotive industry.

His first premise concerned future inorganic materials for major constructions. He believes materials will be limited largely to four metallic elements: iron, aluminum, magnesium, and titanium; and one semi-metal, silicon. He then reviewed the new demands to be made on materials such as ability to withstand higher temperatures, lighter and stronger structures, and higher mechanical properties in bulk metals. The adaptation of metals to systems instead of systems to metals, and application of thermonuclear reactions to make materials with desired properties, are current projects which Kucher predicts will be developed in the next few decades.

Future Energy Problems

Kucher turned his attention to energy problems of the future, reminding the group of the automotive industry's dependence on petroleum, and also of their technical obligation to conserve petroleum. The automotive research industry is "exploring" the adaptability of gas turbines, free-piston engines, and other heavy fuel burning systems, the objective being more efficient ways to convert heat content of raw materials to propulsive energy.

Conceivably, cars could be run by electrical power generated by atomic reactors and propagated by micro-

ANDREW A. KUCHER (above) and a portion of the 2000 engineers (below) are shown attending the May 24 meeting of the Detroit Section. Dinner and technical session were held at the Operations Building of Ford Motor Co.'s new Romeo Proving Ground. Kucher, main speaker for the evening, addressed the audience on "Engineering—Today and Tomorrow."

Progress"

wave beams directed toward the car. The engine might consist of semi-conducting devices and motors of unusual design, made of materials with superior magnetic properties.

Kucher states that silicon will be used as an electronic device to harness the free elections and, eventually, such devices will be developed to convert solar energy into electrical energy, providing an almost inexhaustable supply.

In the field of research, electronic brains will be developed. Electronic brains storing, selecting, searching, coordinating, and directing information for broad ranges are possibilities. New chemical developments are foreseen by submitting specifications to the "brain" with the required structure and synthesis emerging.

Kucher feels the replacement of human labors by machines will produce new opportunities for the population—and the replacement of repetitive functions performed by man with machine operations will give man more time for creativity.

Unlimited Boundaries

In conclusion, Kucher stated, "Engineering progress during the past 25 years has been a phenomenon difficult to comprehend and evaluate in terms of its impact on modern society, for progress has been so rapid we are unable to reach a steady state for proper evaluation." The bounds of engineering are so limitless, Kucher believes we will someday witness and participate in the "Golden Years of Engineering Progress."

Detroit Section Chairman, Charles C. Dybvig, served as chairman of the meeting and John A. C. Warner, secretary and general manager of SAE, was toastmaster. SAE President W. Paul Eddy spoke briefly about SAE. Other prominent engineers seated at the speakers' table included: P. H. Pretz, Ford Motor Co.; B. W. Bogan, Chrysler Corp.; S. W. Taylor, Willys Motors, Inc.; R. M. Critchfield, General Motors Corp.; D. S. Harder, Ford Motor Co.; J. C. Zeder, Chrysler Corp.; E. S. MacPherson, Ford Motor Co.; M. F. Moore, American Motors Corp.; R. F. Kohr, Ford Motor Co.; and R. W. Gaines, Ford Motor Co.

During the course of the festivities, Sarah Duvall, retiring assistant secretary of the Detroit Section, was honored and her successor, Edith McCoy, was introduced.

Mid-Continent

L. W. Okon, Field Editor

FLOODS in Tulsa and tornado alerts did not discourage over 70 members of the Mid-Continent Section and their "dates" that attended the Ladies Night Meeting May 24.

Retiring Chairman Leo A. McReynolds welcomed the feminine contingent and explained to them SAE's service to the engineers present. He encouraged the ladies' pride and sympathy with engineering by comparing the wife's interest in interchange of culinary information to the husband's interchange of engineering know-how.

Philadelphia

E. V. Henc, Field Editor

ENGINEERS of the Philadelphia Section brought their wives to the May meeting for dining and dancing at the Spring Haven Country Club. Highlights of the evening included the awarding of door prizes, and a plaque presentation to retiring Section Chairman Andrew Browne on behalf of the SAE Council, in recognition of his year in office.

SAN DIEGO

R. E. Day, Field Editor

A QUESTIONNAIRE has been sent to all members of the San Diego Section, asking them to evaluate each monthly meeting. The questionnaire included inquiries concerning potential attendance at meetings during July and August; subjects or speakers for future meetings; possible attendance at proposed non-dinner technical meetings; and field trips members would like scheduled. Other general suggestions were invited. Members were also asked to indicate committees on which they would like to serve.

San Diego Section officers approved this questionnaire as part of their continuing attempt to improve the value of the meetings to members.

PITTSBURGH

H. J. Grance, Jr., Field Editor

THE PITTSBURGH section had its annual all-day meeting May 16 at the Wanango Country Club near Franklin, Pa.

Events of the day included golf, a display of foreign cars, a dinner, and technical session. The evening was highlighted by a talk on "'Future Potentialities of the Small Gas Turbine," presented by William St. Germain of Boeing Aircraft Co. St. Germain discussed the various successful applications of the Boeing 502 gas turbine. The advantages and disadvantages of each application were reviewed in relation to the future potential of the small gas turbine.

DAYTON

MEMBERS of the Dayton Section were guests of the Moraine Products Division of General Motors Corp. at the last technical meeting of the 1956–57 season. The meeting was held May 14 and included dinner and a plant tour of the GMC Division.

C. J. Werner, general manager of Moraine Products Division, spoke to the engineers, outlining the product activity of the Division, and elaborating on the principal products.

Dayton Section's June Jamboree was held June 13 at the Springfield Country Club, Springfield, Ohio. This was the annual affair featuring a blind bogey golf tournament, followed by dinner. The event was the wind-up of the year's activities for the Section.

The SAE Canadian Section launched its 1957–58 season at the Oshawa meeting, June 21. Approximately 300 members and guests attended, 90 taking part in a golf tournament and 50 touring the new South Plant of General Motors Corp. where they saw passenger car assembly operations.

Newly elected Canadian Section Chairman E. H. Walker presided. Appearing at the speakers' table (above) are, left to right: E. J. Umphrey, vice-president and director of sales, GMC of Canada; George R. Jackson, secretary of the Section; Edwin F. Armstrong, chief engineer, GMC of Canada; Alex L. Gray, vice-president and general manager, Gray Forgings and Stampings, Ltd.; Lloyd Nourse, president of Wix Accessories Corp.; and Adam F. Smith, president of R. C. Smith and Son, Ltd.

From Section Cameras

George B. Morris, Jr., a senior member of General Motors Corp.'s Labor Relations Staff at Detroit, was the guest speaker at the Oshawa meeting. Morris addressed the members and guests on "Trends in Labor Relations."

New officers were announced at the May 21 meeting of the SAE Hawaiian Section. Chairman Leonard O. Lister, right, is shown receiving the gavel from the immediate Past-Chairman Ivan B. Palmer.

SAE Student chapter at Oregon State College played host to the Oregon Section May 17. Speaker of the evening was Dr. W. F. McCollough, dean of the School of Forestry. Pictured at the dinner table are: Robert V. Kerley, Ethyl Corp.; Art Dillinger; Robert Negstad, SAE Student president; Dr. W. F. McCollough; Professor W. H. Paul; and Ray Smith, newly elected SAE Student president for 1957–58.

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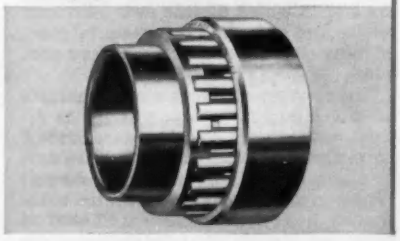

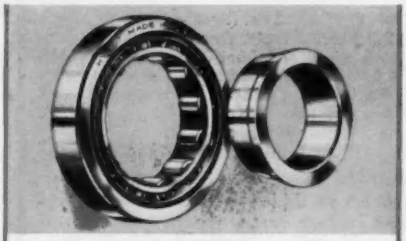

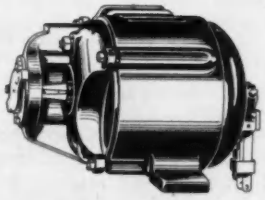

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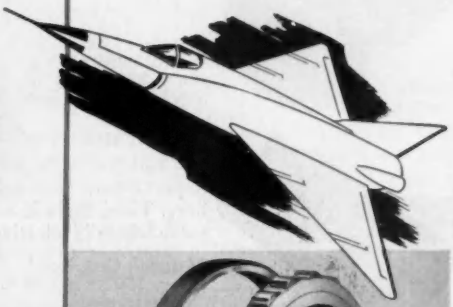

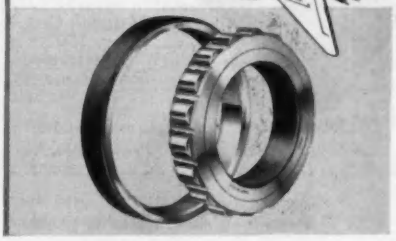

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Why MICROHONING

Is Final Stock Removal Process For Interrupted and Blind-End Bores

To secure low-cost, final stock removal, that generates accuracy and functional surface characteristics in a variety of bore conditions, a leading manufacturer of power steering assemblies uses Microhoning. Here are details concerning types of bores and stock removal results obtained by using Micromatic "Know How"—

STEERING GEAR HOUSING—Microhoning consistently corrects cumulative inaccuracies of preceding operations—reduces scrap—permits faster boring—cuts boring tool sharpenings—lowers down-time and tool costs.

Material: Soft Malleable Iron
Bore: 3.125"D x 6.93"L (Ported bore with ¼" relief at blind end)
Stock Removal: .002"
Finish: 50 Microinches RMS
Microhoning Cycle: 18 sec.
Preceding Operation: Boring

PISTON RACK—Microhoning answers the need for a final stock removal process that generates a controlled surface finish in the bore of this leaded steel part. Microhoned surface (cross hatch) prevents oil leakage and holds to a minimum the wear of seal that operates in the bore.

Material: Leaded Steel (Rockwell 62 "C")
Bore: .875"D x 3"L
Stock Removal: .005"
Finish: 20 Microinches RMS
Microhoning Cycle: 20 sec.
Preceding Operation: Boring and H.T.

VALVE HOUSING—Microhoning consistently holds size and geometric accuracy—meets stringent surface requirements—assures alignment of four lands in bore. Thus, there is no leakage of oil around control valve which is selectively fitted to its housing.

Material: Cast Iron
Bore: .770"D x 2.18"L (Interrupted)
Stock Removal: .0025"
Tolerances: Size .0005"
Roundness .0001"
Straightness .0001"
Finish: 10 Microinches RMS
Microhoning Cycle: 12 sec.
Preceding Operation: Boring

The principles and application of Microhoning are explained in a 30-minute, 16mm, sound movie, "Progress in Precision" . . . available at your request.

☐ Please send me "Progress in Precision" in time for showing on_____(date).
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Continued from page 81

itime Administration, General Motors, and Ford belong much of the credit for pushing this development and to SIGMA of France, too, for the convincing demonstrations provided by their model GS-34. (Talk, "Status of Free-Piston-Engine Development," was presented before the SAE Central Illinois Section.)

Station Wagon Design Challenge to Body Men

Based on paper by

G. F. MACFARLANE,
Mitchell-Bentley Corp.

TO enjoy the challenge of the body engineering profession, but with an extra dash of seasoning, there is nothing like the station wagon business. A station wagon must accompany the most esthetic mood of its owner . . . and also the most utilitarian.

Problems involved in the station wagon—which has grown from 3⅓ to 11⅓% of industry production in five years—are identical with those of other body types . . . with embellishments.

The body builder must, in most cases, start with sedan front ends, doors, and underbodies—which usually have been worked out with studied neglect of station-wagon requirements. Then, he must design the rear structure satisfactorily—despite closed-car engineers. (Take for example, the wheelhouse. In a sedan it is conveniently hidden in the trunk. In the station wagon it is *conspicuously* in the passenger compartment.)

Designing rear-end structures for station wagons is complicated by styling trends which dictate ever-narrower pillars and greater glass areas; by rear-opening structures that must have adequate sealing conditions.

The number of possible combinations in tail- and lift-gate conditions is almost unlimited. (Which gate should open first? Should the gates have one, or many, open or semi-open positions? What type of prop, chain, or cable should hold them open? Should it take two hands to release them for closing?)

Currently popular with some is a rear opening having no lift, or upper gate, but with a drop-glass in the tail-gate. This solves the problem of lift-gate hinges, supports and latches. But it makes for a tail-gate somewhat on the heavy side. Also, it poses problems of sealing and fit.

Sealing the rear surface of a station wagon against dust and dirt is a major problem.

The interior arrangement is most important, too. In the sedan, the rear seat is designed primarily to give

homelike seating comfort. In the station wagen, it should do that too. But it must also be ready to be converted to a segment of cargo floor, having a load capacity akin to that of a fair-sized truck. The seating and leg-room should compare favorably with that of a sedan. But the vertical dimension from the floor to the seat folded should turn a trailer manufacturer green with envy!

The third seat that has to be included in some station wagons adds further complications. To keep this seat from being something of a torture chamber, one approach is to tuck the spare wheel and gas tank between the wheelhouse and quarter panels. This rearview arrangement also makes it possible to fold the seats into the flush —or cargo carrying position—without removing part, or all, of the third seat.

Trim materials and paint combinations in station wagons today involve the same fine fabrics and plastics used in the sedan bodies. On two of the station wagon lines now made by Mitchell-Bentley, 47 exterior colors are available. The two-tone exteriors must harmonize with the three-tone interiors. . . . and the tail- and lift-gates are painted with any one of these five colors—and the inside of the spare tirewell with a six.

The rapid rise in output of the station wagon in recent years has, it is evident, resulted in radical changes in both engineering and production concepts as applied to this body style.

(Paper, "The Station Wagon" presented before SAE Detroit Section on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Electromachining Makes Steady Strides

Based on paper by

C. PAUL PORTERFIELD
Firth Sterling, Inc.

APPLYING electrical energy directly to the workpiece to effect material removal is fundamental to sparkover-initiated discharge machining, contact-initiated discharge machining, and electrolytically assisted grinding. A fourth electro-machining process, ultrasonic machining, uses the combination of vibration and an abrasive slurry to effect material removal.

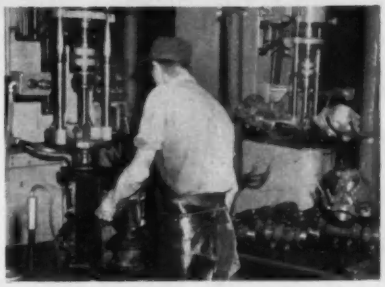
In sparkover-initiated discharge machining, a potential is impressed between the tool and the workpiece. These are separated by a dielectric material, either a semisolid or liquid form. When the potential applied is sufficient to cause a rupture of the dielectric which separates the tool and the workpiece, a heavy discharge current flows through the ionized path. The current

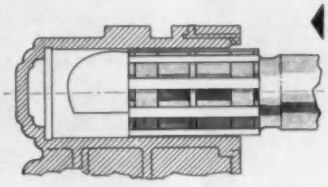
Continued on page 101

How MICROHONING

Cuts Costs—Generates Accuracy—Speeds Production of Interrupted, Blind-End Bores

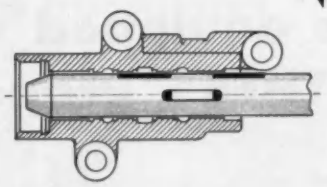
Shown are two Microhoning machines that are used in the plant of a leading manufacturer of automotive power steering assemblies. Machines are equipped with automatic stone feed and stonewear compensating mechanisms, and automatic sizing controls. A two-position rotary fixture is interlocked with machine controls for fully automatic index cycle. The following applications tell more of the "how".





STEERING GEAR HOUSING—In Microhoning the ported, blind-end bore of steering gear housing a nine-stone tool is used. At least six of nine stones are in contact with bore surface when tool passes over irregularly shaped port. Removing .002" of stock from 3.125"D x 6.93"L bore in 18 seconds, Microhoning generates final accuracies and a controlled finish of 50 microinches as specified.

PISTON RACK—In 20 seconds, Microhoning removes .005" of stock from .875"D x 3"L open end leaded steel bore of piston rack. Self-sharpening abrasives assure a consistent generation of specified surface finish of 20 microinches.



VALVE HOUSING—Microhoning tool used for final stock removal in bore of valve housing has one bank of stones and two banks of plastic guides—three stones or guides in each bank. Guides act as tool pilots and stabilizers in interrupted bore—prevent overcutting at edges of lands—assure straight bore by keeping tool aligned. Self-dressing abrasives consistently generate geometric accuracy of .0001" and surface finish of 10 microinches.

Microhoning economically removes stock—corrects cumulative inaccuracies of preceding operations—reduces scrap—permits faster boring—lowers machine tool downtime and maintenance to cut costs and speed production.

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Learn how Microhoning will give efficient stock removal, closer tolerances, accurate alignment and functional surfaces.

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emanates from a point source on the workpiece and produces in it, under the point source, high current densities which generate electrical force fields. These fields effect material removal. The workpiece is always the anode and the tool or electrode is always the cathode.

Energy is fed to the so-called working gap in the form of time-spaced pulses of energy. These pulses must be used to allow the dielectric to heal and become an insulator before it is ruptured by the potential gradient generated by the next voltage pulse. The function of the dielectric is to provide a path capable, when ionized, of maintaining a current density of sufficient magnitude to effect material removal. If the dielectric does not deionize, current densities will be insufficient to effect material removal and the energy generated will be expended in the form of heat. There is no physical contact between tool and workpiece in a properly functioning unit.

Contact-Initiated Discharge Machining

In contact-initiated discharge machining the discharge is initiated by allowing the tool to contact the workpiece. After initial contact the tool is withdrawn and an arc is allowed to form. The tool is normally positioned in synchronization with the line frequency of the low-voltage alternating-current source which is connected to the tool and the work. During the time interval that an arc is allowed to exist between tool and work, the temperature rises at the terminus of the arc. If a coolant (usually in the form of water) is applied, the resultant thermal shock will cause localized fracture of the material being machined and work will be performed. This type of equipment can be operated with a direct-current source, in which case the duration of the discharge is controlled by the reciprocating motion of the electrode. With a direct current source the workpiece is normally of positive potential. Material removal is by thermal shock.

Use of this arc machining operation is restricted to removal of broken taps or similar repair operations. Rough machining may be done if the metallurgical changes associated with the technique are unimportant in the finished part.

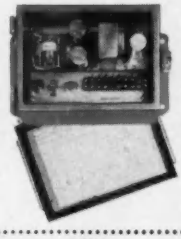
Electrolytically Assisted Grinding

In electrolytically assisted grinding it is the flow of current through an electrolyte, which separates the work and tool electrodes, that does the work. This separation is effected by a single layer of diamonds on the grinding wheel electrode. The diamonds also brush away the metal oxides or metal salts which are formed on the work as a result of the current flow from the work through the electrolyte to the wheel. Were these oxides not removed,

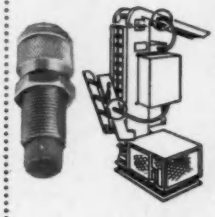
Continued on page 103

Now . . . "automate" operations with metal sensing transducers

Control or count without contact

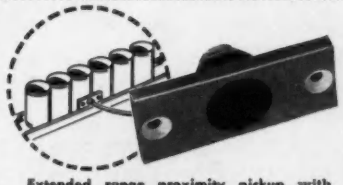


Proximity control unit in JIC enclosure for use with transducers shown. System detects ferrous and non-ferrous metals. For automatic production lines, multiple process machines, parts feeders, conveyors. Maximum rate 600 operations/minute. 4905-RAC $85.



Standard proximity pickup. Detects small metal objects at speeds down to zero. Use for automatic feed, etc. 4910-AN $16.50

Water and oil proof proximity pickup. 4910-WPN $45.00



Extended range proximity pickup with greater sensitivity than 4910-AN. 4915-AN $22.50.

Pancake proximity pickup. Detects large metal masses at greater distances than 4915-AN. 4925-AN $36.50.

Hollow coil proximity pickup. Use for control, batching, switching, automatic operation. Counts small and medium sized parts. I. D. ¼" to 3". 4920-AN $36.50.

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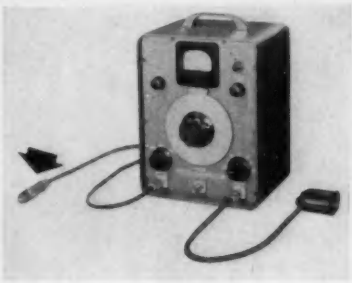
NEW PRODUCT NEWS



Kistler Indicator Measures Engine Pressure Changes Quickly and Precisely

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Pressure changes generating an electrical charge in the Swiss-made SLM Pressure Pickup are measured by an electrostatic type amplifier and displayed on an oscilloscope. Small pressure variations in overall cylinder diagrams can be magnified as much as a thousand times. Rugged enough to withstand diesel combustion and other temperatures up to 600° F, without special air or water cooling, the pickup will measure combustion pressures for all ranges, 0.1 through 3000 psi. With the addition of a Kistler adaptor, fuel injection pressures to 20,000 psi can be measured.

The ability of the SLM Indicator to measure directly either *pressure* or *rate* of pressure changes, makes it invaluable for fuel, combustion and detonation studies, load balancing, monitoring, peak pressure adjustment on production engines, and maintenance or repair operations. The most advanced engine analyzer available, it can be operated as readily as a TV set. Trouble shooting and ignition or injection timing are greatly simplified. Optional equipment includes a selector switch which permits operation of several pressure pickups with a single amplifier-calibrator unit, and a piston displacement indicator for direct display of traditional indicator diagrams.

For complete information on the SLM Pressure Indicator, including Swiss-made SLM Pickup, special low-noise cables and the Kistler "Piezo-Calibrator" (amplifier-calibrator), request Bulletin EPI-114.

Kistler Instrument Corp., Dept. SA, 15 Webster St., North Tonawanda, N.Y.

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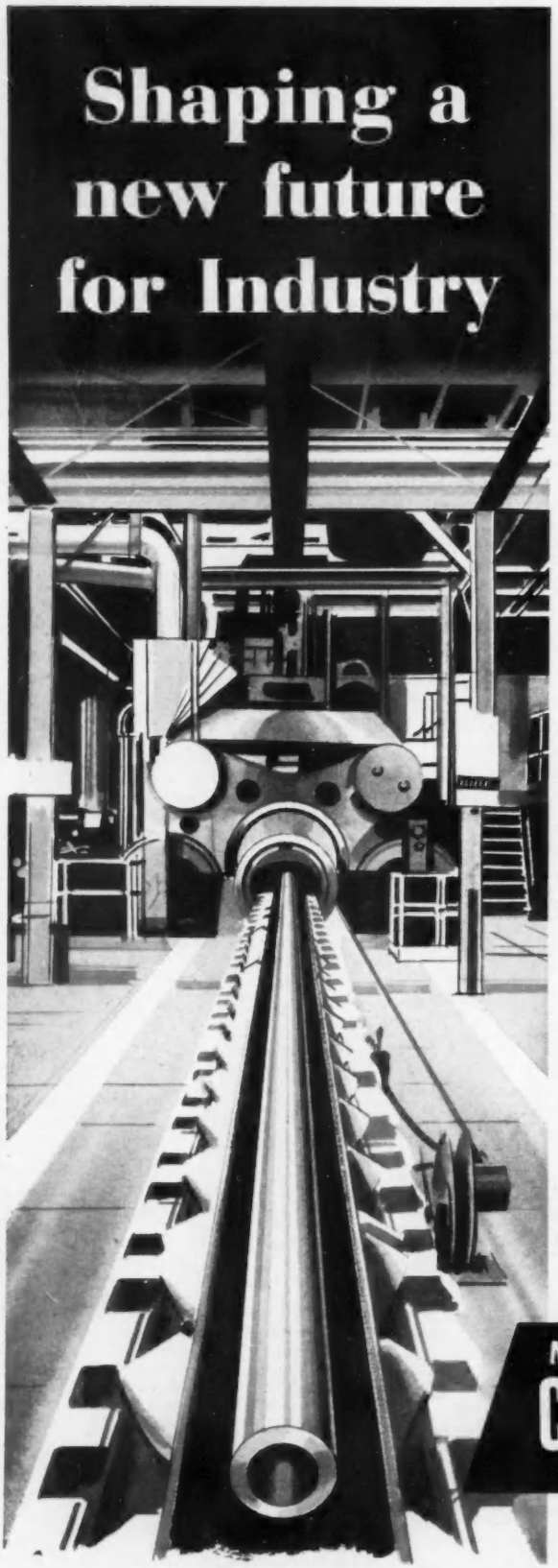

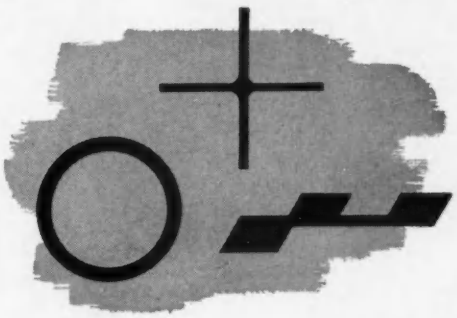

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they would build up an insulating layer and the machining action would decrease steadily in effectiveness. It is virtually impossible to remove the salts without touching the parent material, hence some diamond wear does occur, but the rate of wear is far less than that common to conventional diamond grinding.

The workpiece normally is of positive potential and the grinding wheel is negative. The liquid which separates wheel from work must be capable of carrying electrical current. In effect, this is a reverse plating action supplemented by the diamond grinding which keeps the oxides from stopping the deplating action.

Ultrasonic machining is the only one of this group of machining operations which does not apply electrical energy directly to the workpiece. The work is submerged in a slurry of finely divided abrasive in a vehicle which is normally water. The tool is coupled to a magnetostriction oscillator and is caused to vibrate at very low amplitudes at a rate of 15,000–30,000 cps. The travel of the moving tool drives the slurry into the workpiece and the abrasive in the slurry removes the material. This is actually an abrasive process.

(Paper, "New Machining Techniques Made Possible By Electro-Machining" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Off-Highway Vehicles Showing Steady Advance

Based on paper by

E. R. STERNBERG
Autocar Division, White Motor Co.

A look at today's off-highway, rubber-tired, rear dump vehicles reveals new trends in engines, torque converters and transmissions, axles, hoists, and bodies.

Horsepower is on the increase. In the 15–18-ton vehicle class, horsepower has jumped from 165–200 to 200–250. Some operators want still more. In the 22–25-ton class, horsepower has gone from 275–300 to 335 as standard, with 375 hp optional.

The latest trend in engines is toward turbocharging, higher-speed (2500 rpm) V-8 diesel engines, and greater use of 12-cyl engines. Further increase in horsepower per cubic inch of piston displacement and per pound of engine weight can be expected.

Torque converters are being used to reduce shock loading of the drive components. These take the form of single-stage converters with torque multiplication at stall up to 3½/1, and 3-stage converters with torque multiplication of 5/1 at stall. While the converter introduces inherent inefficiencies in the drive system, these losses are offset by an increase in the engine load factor.

Many torque converter equipped units are used with 3- or 4-speed planetary gear transmissions, which can be shifted under full power. This is extremely valuable in off-highway service and particularly where the going is soft. Another valuable feature is a hydraulic retarder built into the converter or transmission. This permits a control of fully loaded vehicles on steep grades with little or no use of the service brakes.

Important to transmissions has been the development of units suitable for 400-hp engines, with and without torque converters. Fuller has a 4-speed transmission for use with a torque converter; Cotta has a 3-speed one for similar conditions. Mack has a 4-speed transmission for use with a converter and an 8-speed one for use without converter. Larger transmissions are in process of development to permit the use of single engines of more than 400 hp.

Axles have been given greater capacity and made more readily accessible for servicing. Tracks are wider to permit the use of larger tires. Practically all off-highway rear dumpers are now equipped with planetary gear drive rear axles, with the planetary reduction

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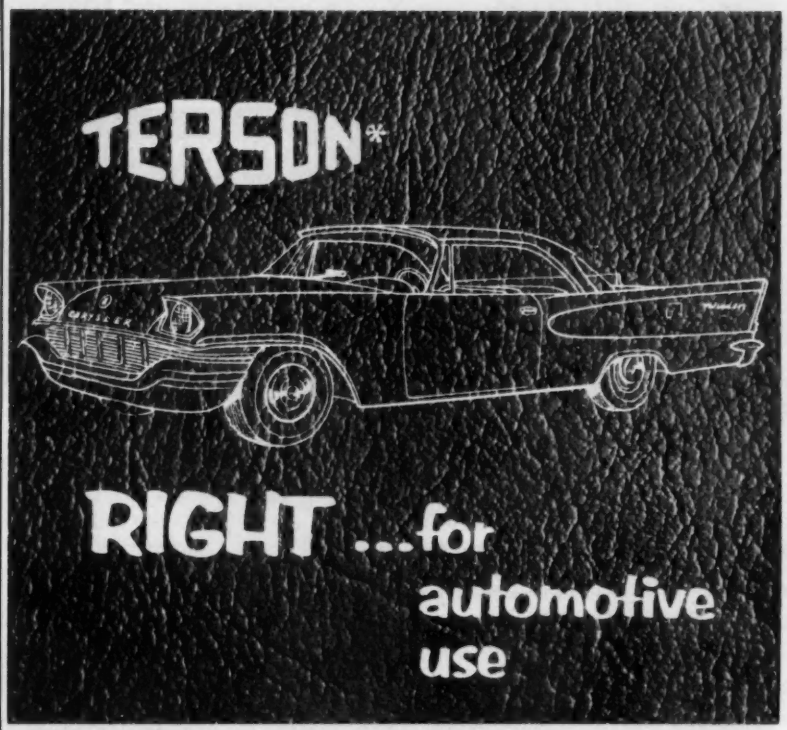

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Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

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THREAD CUTTING FASTENER

Re-usable, self-locking, vibration-proof fastener cuts clean, deep threads on unthreaded chrome-plated studs. Available for 1/8", 5/16" and 1/4" studs.

PLUG BUTTONS

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Holds on smooth, die-cast metal or plastic studs to anchor name plates, trade marks etc. on appliances, automobiles, electronic apparatus, etc.

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Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration proof attachment. Permanent or removable. Many shapes and sizes.

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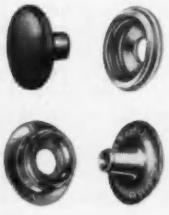
Re-usable, self-locking, one-piece, all-metal nut has high tensile strength, is unaffected by heat or oils. In various shapes, sizes and metals.

SOL-A-NUT

Self-locking, rustless, heat resistant. Sturdy, one-piece stainless steel construction prevents corrosion if nicked or scratched.

DURABLE DOT FASTENER



Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

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MAKERS OF DOT FASTENERS

taking place at the axle outer ends. Rear springs are coming into use.

Early hoists operated at approximately 700-psi pressure. Pressures are now close to 2000 psi and within the next 5–10 years will probably reach 3000 psi. Dump bodies are being made of thicker material to increase life and high tensile steel wear plates are being introduced.

Under experiment are alminum bodies. Since tire capacity imposes load limits, any lightening of the body would be helpful. Claims for aluminum are that it affords greater dent resistance and that it will give rather than tear or break under impact. Greater corrosion resistance would be an assured asset.

(Paper "Developments In Off-Highway Vehicles" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Airlines Want Economy In Maintenance and Fuel

Based on paper by

FRANK W. KOLK
American Airlines, Inc.

THE main requirements of commercial engines are low mechanical costs and low fuel costs to do the assigned task of transportation.

The two important features in this respect are low premature removal rate and low specific fuel consumption.

Gas turbines—particularly turbojets—will apparently be considerably cheaper to operate from a line maintenance viewpoint than piston engines in current use. If anything happens to a jet engine so that it will not operate properly, it must be removed or, at least, a portion of it must be removed. Examination of the Pratt & Whitney Aircraft maintenance manual for the J57 shows the trouble-shooting chart to take up 10 pages. The same chart for the R-2800 CB-16 takes up 60 pages. There are, in fact, only two adjustments which can be made in the J57 when it is installed. These are the maximum and the minimum fuel flow.

Thus, it is most likely that the costs of maintenance on the line are very low. Most of the mechanical costs of operation are in the costs of overhaul.

The inference is very clear. A good commercial engine must be designed and operated so as to maximize longevity and minimize breakdowns.

Estimated overhaul costs for jet engines range all the way from $75 per hr for 600 hr between overhauls at 2×10^{-3} failure rate down to $13 per hr for 2000 hr between overhauls and 0.2×10^{-3} failure rate. With such a percentage spread available from these factors, the business of trying to guess at the operating cost level of a new engine, using data shown on the engine specification is pretty unrewarding. It is quite possible to have an aircraft, inferior when judged on the basis of estimated costs, be superior in practice because of the installation of what turns out to be a superior engine from a premature removal viewpoint.

Hence, it is very desirable, from a consumer's point of view, to have engine salesmen back their claims of mechanical excellence with a guarantee that the mechanical costs of operating an engine will not exceed a reasonable maximum. This is because, if a high premature removal rate is encountered, redesign of the critical parts of the engine may be the only means of ever achieving reasonably low-cost operation.

For best fuel economy, it is important that the engine be so designed that it operate in cruise at very near to the best possible cyclic fuel economy. Unfortunately, the specific thrust of such an optimum engine is quite low—about 37 lb thrust per lb fuel per sec.

Most present day engines are designed to function at specific thrust

Continued on page 106

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values of 40 to 45 lb thrust per lb fuel per sec for cruise. It would appear that vastly lower fuel costs per ton-mile would be available if engines of low specific thrust were available. It is likewise interesting to see that the optimum temperature is about 900 F for the turbine inlet. This is considerably lower than the temperatures currently used for cruise in most jet engines.

The use of the bypass engine and the turboprop can be considered as means of reducing the cost of operation. It would appear to this observer that the most promising arrangement for the future lies in the bypass engine. However, to achieve the desired overall efficiency, it is necessary to so proportion this engine that it is more efficient, fuel-wise, than the optimum jet engine. It is not at all obvious that this can be done. Certainly the present tendency to build such engines at about the same fuel economy but somewhat lighter than corresponding straight jets will not contribute the greatest benefits. The most important improvement now sought in aircraft powerplants, particularly of the reaction type, is the reduction of the cost of fuel consumed on a per ton-mobile carried basis.

(Paper, "Study of Engine Characteristics Best Suited for Commercial Transports" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Engineering Production Ties Need to Be Closer

Based on talk by

GENERAL J. T. McNARNEY
Convair Division, General Dynamics Corp.
(As reported by Charles Cates, SAE Texas Section Field Editor)

ENTIRELY new methods for handling the materials required by coming missiles, supersonic aircraft, and nuclear craft must be devised. New machine tools must be designed to work with the new materials and to meet tolerance much closer than the industry is now accustomed to.

Management must re-examine the new concepts and provide the new link in the "communications" system of aircraft production.

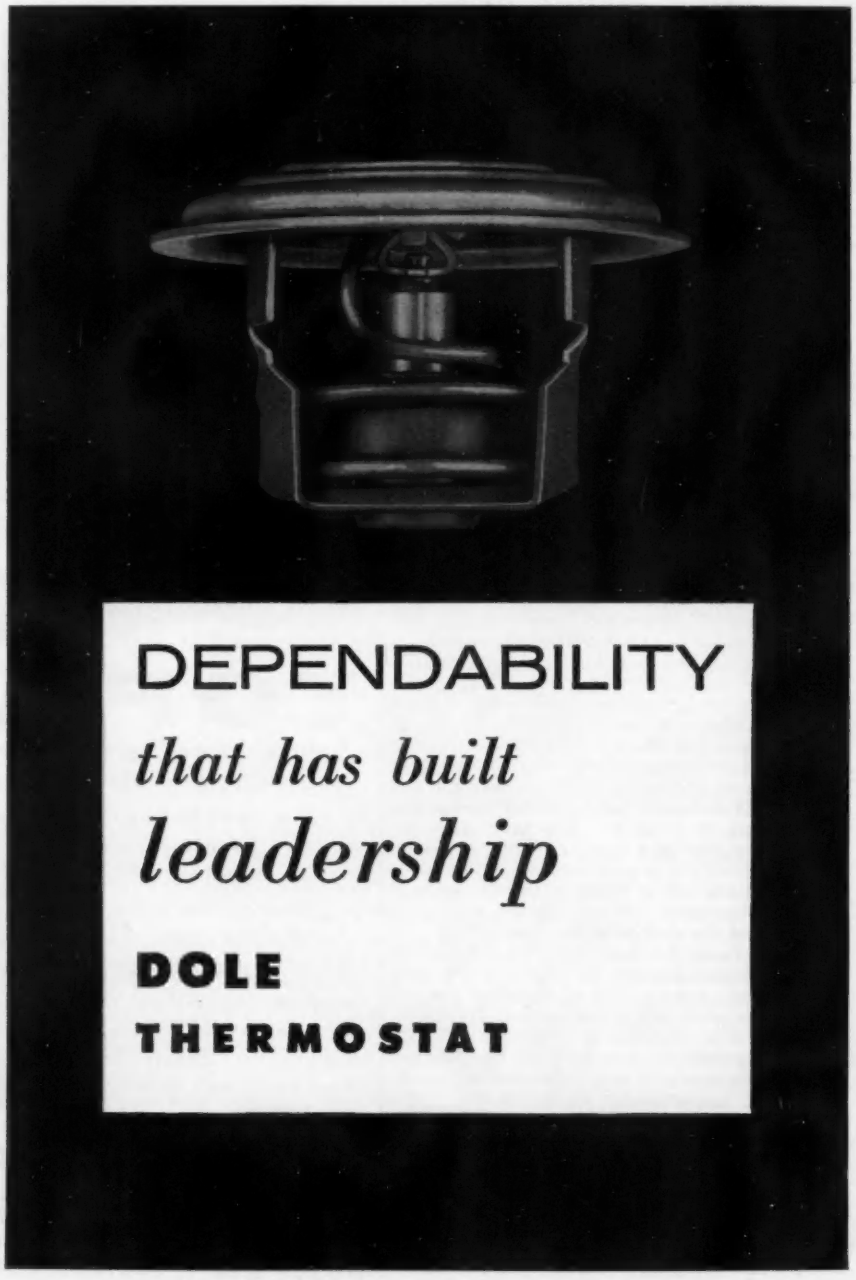
The forging of this missing link in the communications chain will benefit all key personnel by leaving time for the manufacturing staff, give the designer more confidence as he proceeds, and save both time and money by proceeding only as fast as the new technological data permit—reducing trial-and-error practices.

It is increasingly necessary for aircraft production management to provide a closer relationship between the engineers and production supervisory personnel.

It is no longer possible for design and development engineers to draw blueprints of a craft and turn them over to manufacturing personnel and say, "here it is, build it."

The scientific challenges confronting us in licking the thermal barrier require not only a great amount of new scientific information but the translating of that knowledge to the shop people, who no longer will have time to keep pace with technological requirements and put the craft in the air, too.

The new "technological engineer" must help correlate all phases of operations by being the eye for production executives on the proposed craft or missile from its very inception. He must know the findings of those who solve the metals problem, for instance, of weapons that must travel at 2–4 times the speed of sound, when skin temperatures of 800 F and over are developed.



Research Aims At Better Axle Life

Based on paper by

LEONARD RAYMOND
Socony Mobil Oil Co., Inc.

AXLES are going to have a tougher, rather than easier, job in the future. In certain instances, the axle may be the key to vehicle design. Recognition of problems lying ahead is encouraging more research and better facilities for carrying it out.

There is more work being done to analyze gear stresses under dynamic conditions. Due to the unsteady nature of the powerplant and the axle load, the dynamic loads on the gear teeth can be much greater than those computed on a constant torque or load basis. The Armour Research Foundation is in the midst of an excellent program of determining instantaneous and peak gear loads, using special methods and instrumentation.

Temperature level is an extremely important factor in axle performance. Builders recognize that bulk-oil temperatures in excess of 250 F are detrimental to gears, bearings, and lubricant, yet the temperature load seems to be getting greater than desirable with current products. To overcome this difficulty through design, metallurgy, or lubrication, it may be necessary to apply real effort. The builder may need new gear steels having a higher hot strength and less tendency to such things as surface decarburization and annealing at temperatures above 250 F. The lubricant supplier may find a way to combine excellent antiweld activity with an even better thermal and chemical stability at high temperatures.

The current cooperative effort manifest by the Coordinating Research Council augurs well for the future. Such cooperative effort may be even more vital if different gear forms are adopted or if axle and transmission combinations requiring new lubricant of fluid performance enter the picture. A real problem would be posed by such a possible combination as an automatic transmission-hypoid axle unit utilizing a common lubricant.

(Paper "Improved Axle Life—A Three-Way Responsibility" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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In 1952 Dole introduced the first satisfactory solid expansion type thermostat engineered especially for post-war engines.

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Exhaust Gas Hydrocarbons Studied

Based on paper by

J. N. SHINN
Yale University (now with General Electric Co.)
and
D. R. OLSON
Yale University

THE majority of hydrocarbons appearing in the products of combustion are associated with phenomena occurring at the combustion-chamber walls, such as flame quenching and fuel condensation. This is indicated both by studies in actual engines and in a special combustion apparatus.

It appears, further, that the exhausted gases may not constitute a representative sample of the total combustion-chamber products, since the products close to the walls are not entirely exhausted.

Thus, the residual gases that remain

Continued on page 109

Once again – proof Sealed Power leads in

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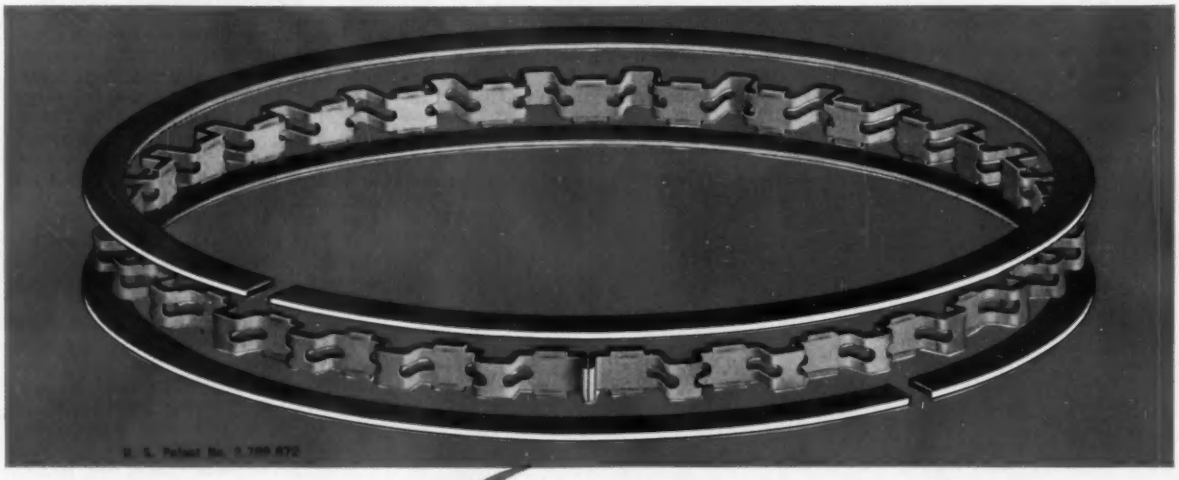

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Stainless Steel Oil Ring

Three undeniable material advantages:

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2. Highly resistant to corrosive elements found in internal combustion engines.
3. This stainless steel hardens and develops more resistance to wear in use. This means longer life than carbon steels deliver.

Four important design advantages:

1. Uniform high radial pressure against the cylinder wall assures efficient oil distribution, maximum oil control.
2. Axial pressure of the stainless steel expander forces side rails snugly against side of groove. This prevents oil waste due to high vacuum, makes the ring side-sealing.
3. Circumferential pressure of the expander makes the ring conform to the bore without touching bottom of groove.
4. Quick seating assured by Sealed Power's method of chrome-plating steel side rails. Breaks in fast, gives more than double normal ring life.

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in the combustion chamber contain a considerably higher percentage of hydrocarbons than the exhausted products. This difference is greatly augmented when the chamber wall temperatures are sufficiently low to produce condensation of the fuel.

It seems possible that these effects may play an important role in deposit formation on combustion-chamber walls and could be affected by fuel type and combustion-chamber design.

(Paper "Some Factors Affecting Unburned Hydrocarbons in Combustion Products" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers. The original paper is from the dissertation for a doctorate of engineering degree from Yale University.)

More Accurate Measure Of Jet Thrust Described

Based on paper by

MARTIN J. SAARI
Lewis Flight Propulsion Laboratory, NACA

THE utilization of a thrust-measuring principle based on the nozzle pressure parameter provides an accurate, simple, and reliable indication of jet thrust for application to jet transport operation. The principle is valid for all operating conditions at which the engine exhaust nozzle operates in a choked condition.

A schematic diagram of such a thrustmeter installation is shown in Fig. 1. An integrating total pressure probe was used to sense the total pressure at the turbine outlet. This signal was fed into a pressure-multiplying relay that produced an outlet pressure of 1.26 times exhaust-nozzle-inlet total pressure, which, in turn, was fed to one side of a sensitive differential pressure gage. (It should be noted that, in this case, the multiplying relay was adjusted to account for the pressure drop between the turbine-outlet and exhaust-nozzle-inlet stations.) Free-

Continued on page 112

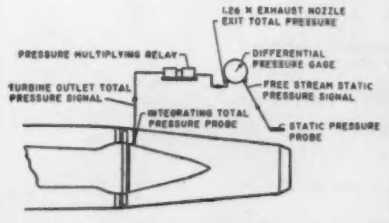
1.26 × EXHAUST NOZZLE EXIT TOTAL PRESSURE
PRESSURE MULTIPLYING RELAY
DIFFERENTIAL PRESSURE GAGE
TURBINE OUTLET TOTAL PRESSURE SIGNAL
FREE STREAM STATIC PRESSURE SIGNAL
INTEGRATING TOTAL PRESSURE PROBE
STATIC PRESSURE PROBE

Fig. 1—Schematic diagram of thrustmeter installation.

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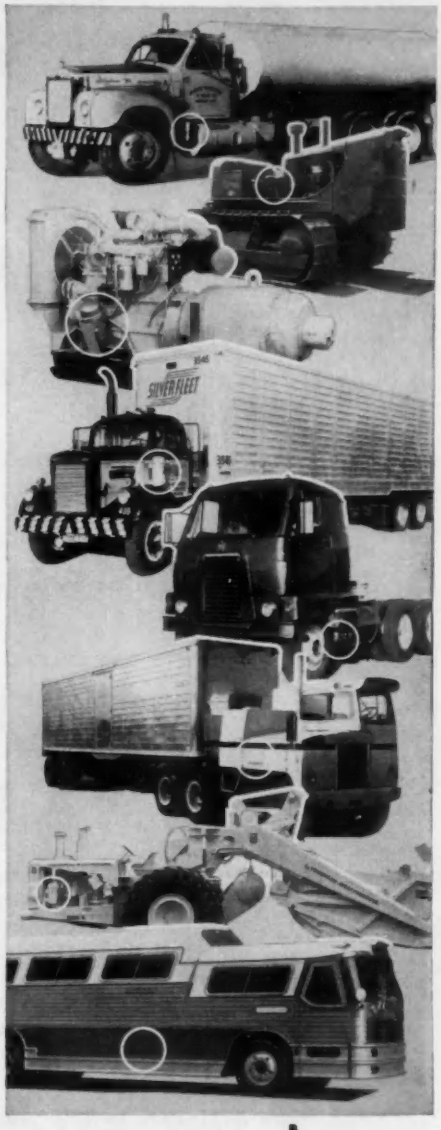

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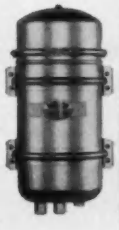

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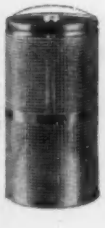

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stream static pressure was sensed in the plane of the exhaust-nozzle exit and was fed into the case vent of the differential pressure gage.

The installation of a thrustmeter in a jet transport, therefore, requires only the definition of the relationship of measured jet thrust with the exhaust-nozzle pressure drop parameter for the particular type of engine to be used. This relationship can be established from a single data point at static sea-level conditions. The exhaust-nozzle thrust coefficient and measured nozzle exit area would be used as constants in deriving the scale on the thrustmeter dial. If exhaust-nozzle geometries other than the simple circular convergent nozzle are used, such as special geometries dictated by jet noise suppression requirements, the thrust coefficient must be obtained from nozzle calibration data or the thrustmeter correlation must be established for the particular engine-nozzle combination in a test stand calibration.

(Paper "Thrust Measurement for Jet Transport Operation" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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DC-8 Undergoes Range Of Pre-Flight Tests

Based on paper by

H. W. ADAMS
Santa Monica Division,
Douglas Aircraft Co., Inc.

As a result of the extensive pre-flight development effort expended on the current jet transports, we are confident that these airplanes will perform satisfactorily when first delivered and will continue to do so over a long and useful service life.

Structural fatigue testing covers the entire range from tests of large portions of the fuselage through panel tests with various constructions to innumerable detail fatigue tests of joints and fittings. The loads applied depend on the specific structure being tested; they come from three principal sources: pressude cabin cycling, flight gust loads, and acoustic pressure loads. In general, the pressure cabin cycling tests are critical for fuselage skin panels and internal structure. Gust loads are critical for the wing and tail structure. Acoustic loading is critical for the lighter structures used in control surfaces, unstressed wing surfaces and similar regions.

All of the major systems in the airplane are tested as a complete system after each component has been separately tested and developed. For instance, the pneumatic and air conditioning systems are duplicated on the left and right sides of the airplane, so one complete half system is tested. This test is only run after development of the components such as valves, cabin superchargers, and deicing systems is complete and insured by functional and life tests under the most adverse operating conditions.

The electrical system on the DC-8 is an alternating current system, which is a radical change from the direct current system used on previous airplanes of the DC series. For this reason, an extremely thorough system test was planned. The generating system was set up with four diesel engines representing the airplane's engines and was run under all conditions of operation including the simulation of various malfunctions. In addition, of course, all the components were tested separately.

The powerplant testing involves, besides the operation of a complete pod, the development and testing of sound

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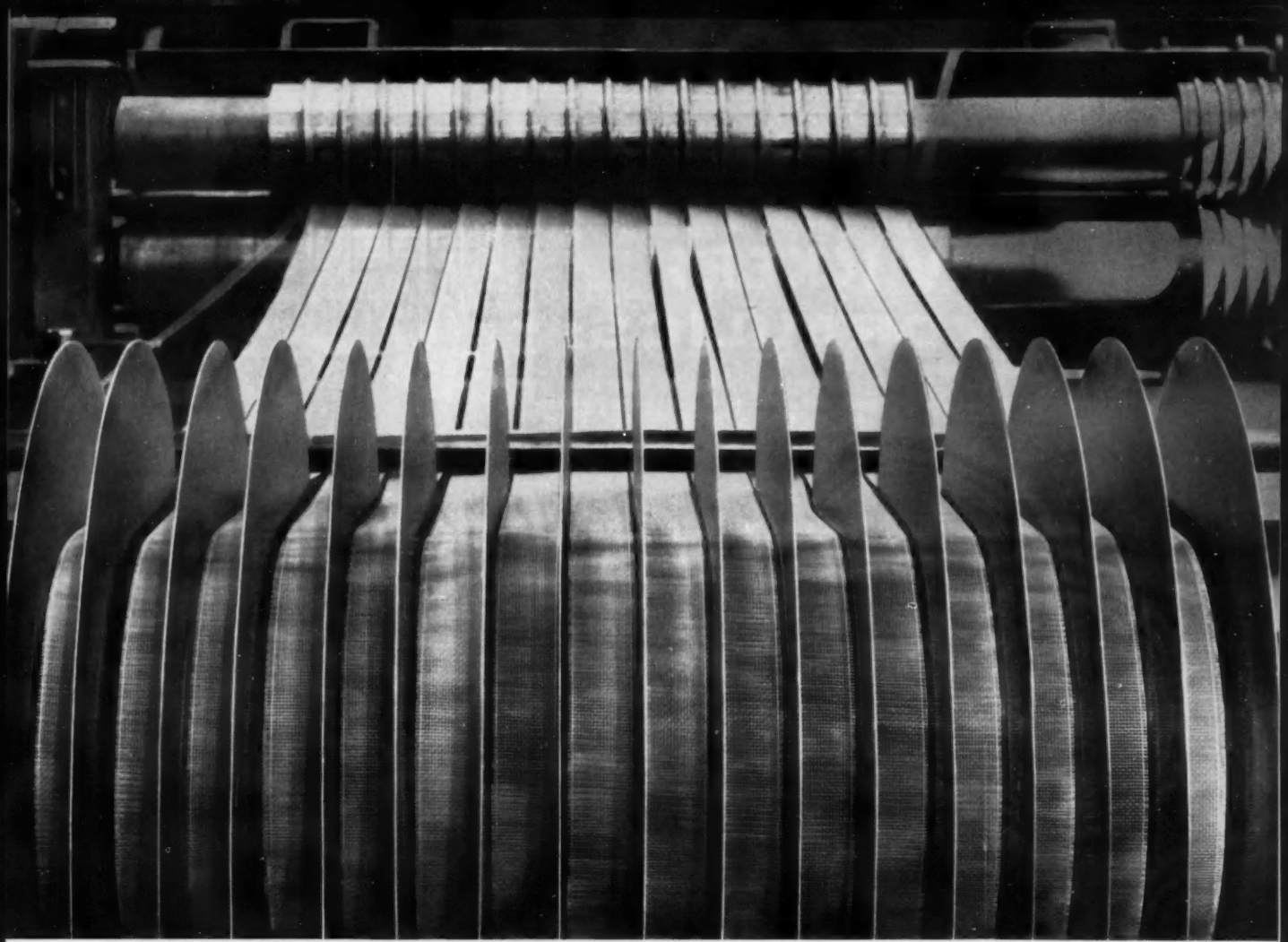

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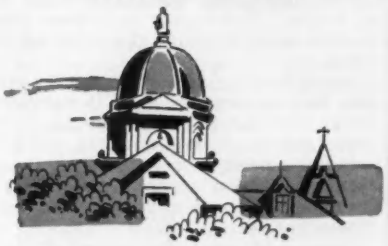

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suppressors and thrust reversers. These are new problems peculiar to jet transports.

Jet transports, flying at higher altitudes, require more development to insure the comfort and safety of the passengers and crew. In the interest of crew safety, hail- and bird-proof tests are run on the windshield and structure ahead of the pilot. In the interest of good visibility, a hot-air-jet rain-removal system was developed to replace windshield wipers, which seem to be inadequate at jet speeds. The use of the flight simulator during preflight development is a step that is being taken on the DC-8 to get evaluation of airplane safety under simulated flight conditions so risky that they could not be tried on the actual airplane.

In the interest of crew and passenger comfort, replicas of the cockpit and the cabin have been built and tested from −100 to +120 F outside air temperature.

(Paper, "Preflight Development of Modern Aircraft" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Aluminum Increases Earthmover Payload

Based on paper by

W. C. WELTMAN,
Aluminum Co. of America

THROUGH the judicious use of aluminum alloys in proved applications, a 10–15% increase in earthmover payload capacity can readily be achieved at no increase in gross vehicle weight.

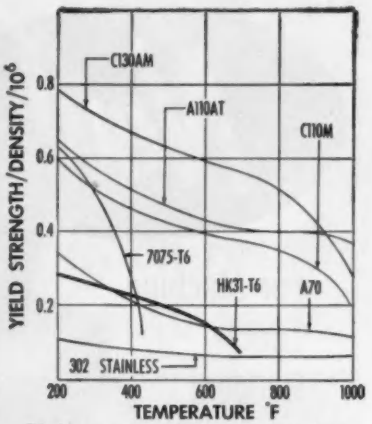
Aluminum equipment has and is being used on highway and general-purpose construction work to move sand, cinders, salt, gravel, bulk cement, and earth and rock fill. The weight savings over steel—depending on the size of the unit—varies from 1,500–2,500 lb for dump bodies mounted on a straight truck. On dump trailers, 2,300–3,200 lb of weight can be saved.

As a rule, aluminum will provide a 50% saving in weight over the steel unit it replaces. Only a modest increase in the height of body sides or in the length of a body is required to handle the increased payload.

In off-highway hauls, benefits from using aluminum have been even more spectacular. The weight saving gives the operator 10–15% greater payload for the same gross vehicle weight. This means an extra profit yield to the operator of 1½–4¢/cu yd of material hauled.

Should a fixed number of cubic yards be required in a prescribed time, as in

Continued on page 116



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Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.

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most mining operations, the number of trucks required for the job could be cut 10%. In short, nine trucks equipped with aluminum bodies would do the work ordinarily calling for ten trucks.

Computing ownership and operating costs at approximately $12.50/hr per truck, the savings in eliminating one truck would amount to $100 in an 8-hr day. On a yearly round-the-clock operation, savings at this rate could exceed $100,000.

Aluminum units have been built and operated to prove the economies claimed. The largest is a 69-cu yd bottom-dump coal hauler. The use of aluminum in this unit saved 10,000 lb of weight. This hauler and others like it have been in steady operation since 1953.

Another, a 28-ton capacity rock body has been in operation since September, 1956. The weight savings in this unit was 7,000 lb. It has operated 600 hr, and has needed no more servicing than would have been required of steel bodies under the same, rigorous conditions. There has been no major difficulty.

Many additional applications of aluminum are being considered for earthmoving equipment, and many are now under test. Experience with both commercial and experimental applications is mounting rapidly. The aluminum alloys and welding techniques have been proved and are available. Further consideration by the design engineer is hastening the day when the use of aluminum in earthmoving equipment will be general, affording increased efficiency to both operator and builder alike.

This abridgment is based on paper "Aluminum in Earthmoving Equipment" presented at SAE Central Illinois Section's Earthmoving Industry Conference, March 26–27, 1957.

Automotive-Petroleum Partnership is Economic

Based on talk by

J. A. EDGAR

Shell Oil Co.

(As reported by C. A. Barrand, SAE Southern California Section Vice-Chairman, Fuels & Lubricants)

THE partnership between the automotive manufacturer and the petroleum industry has come a long way over some very rough spots. The partnership must always be an economic one and, therefore, is subject to compromises. An example of this is the use of the hypoid rear axle, which not only lowered vehicle lines but resulted in a 25% reduction in weight and material. The hypoid axle, however, imposed severe requirements on the lubricants, and it was only through the petroleum industry's product development that the hypoid axle design was saved from the junk pile.

Another example was the difficulty encountered in valve gear assemblies

Continued on page 118

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AUTOMOTIVE ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON

ZYTEL® nylon resin

Now—versatile Du Pont ZYTEL® nylon resin used in a wide variety of improved auto parts

The use of Du Pont ZYTEL for structural and mechanical parts is constantly expanding. The moldability of ZYTEL makes it a natural for use where millions of units are required. Its high strength in combination with other high-grade properties is especially valuable in the automotive industry.

As an example, ZYTEL offers a combination of toughness, abrasion resistance and hardness for making automotive gears. Another important asset of ZYTEL as a gear material is its resilience. This is the ability of the material to yield under pressure and return to its original state when pressure is released. This property plus its low coefficient of friction permits ZYTEL to outperform steel at ordinary temperatures. Tooth errors which are usually destructive, such as pitch variations, profile error and excessive runout, are minimized at the instant of engagement.

ZYTEL nylon resin is extremely wear-resistant. Both gears and sleeve bearings of ZYTEL tested in the presence of abrasive materials such as sand have outworn metal components by far. Parts of ZYTEL require little or no lubrication.

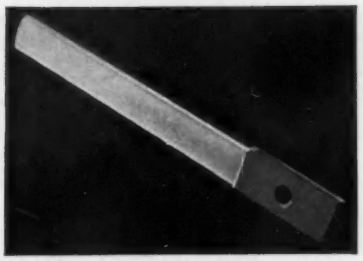
A valuable characteristic of ZYTEL is its resistance to petroleum lubricants. It will not swell or deteriorate in contact with oils, greases, hydraulic fluids or gasoline. Designers can specify lubricated gears, bearings and bushings of ZYTEL without fear of failure.

Frequently, a single part of ZYTEL can replace a number of metal parts, thus eliminating machining and assembly operations. For example, a single speedometer part includes a worm gear, pinion and four different shaft diameters, all molded in one. The economy of such parts is obvious.

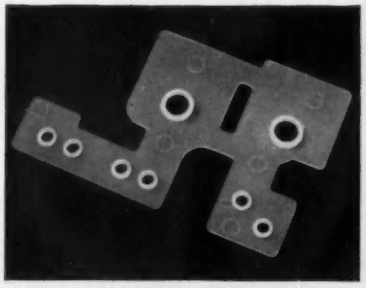
Parts of ZYTEL can be molded directly onto metal pieces. A combination often used is a gear of ZYTEL with an imbedded metal shaft. ZYTEL is rated for intermittent operation up to 250°F. For continuous operation at such elevated temperature, heat-stabilized grades are available. For decorative uses, it is available in rich, deep colors, including metallics.

It may well be possible to make your sub-assemblies better at lower cost by using durable parts of Du Pont ZYTEL—as you will be able to judge if you send for the informative material we have made available. Get the facts by using the coupon below.

Eight of these large main hangar bushings made of ZYTEL are used per trailer; sixteen of the smaller shackle bushings go into the trailer's torsion-bar suspension system.

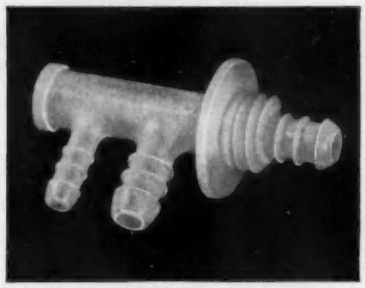


Anti-rattle plate is extruded from ZYTEL 42. Thin, uniform sections of ZYTEL nylon resin absorb shock and vibration without damage. (Extruded by Anchor Plastics Co., Inc., Long Island, N. Y.)

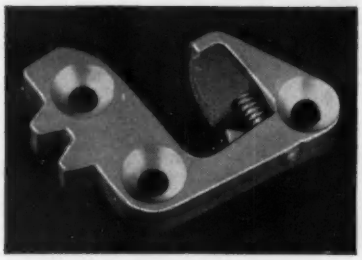


Voltage-regulator base made of ZYTEL provides good electrical insulation . . . is highly resistant to cracking under mechanical stresses.

Thin sections of ZYTEL are translucent, yet strong and flexible. This lens is heat-resistant. Molded projections simplify attachment.



Smooth, accurate moldings such as this windshield washer T-connection reduce cost of sub-assemblies. Note integral mounting threads.



Hard, smooth door-lock wedge of ZYTEL needs no oiling. Spring-loaded, it operates efficiently due to low inertia . . . resists shocks.

SEND FOR INFORMATION

For additional property and application data on Du Pont ZYTEL nylon resin, clip and mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 58, Du Pont Building, Wilmington 98, Delaware

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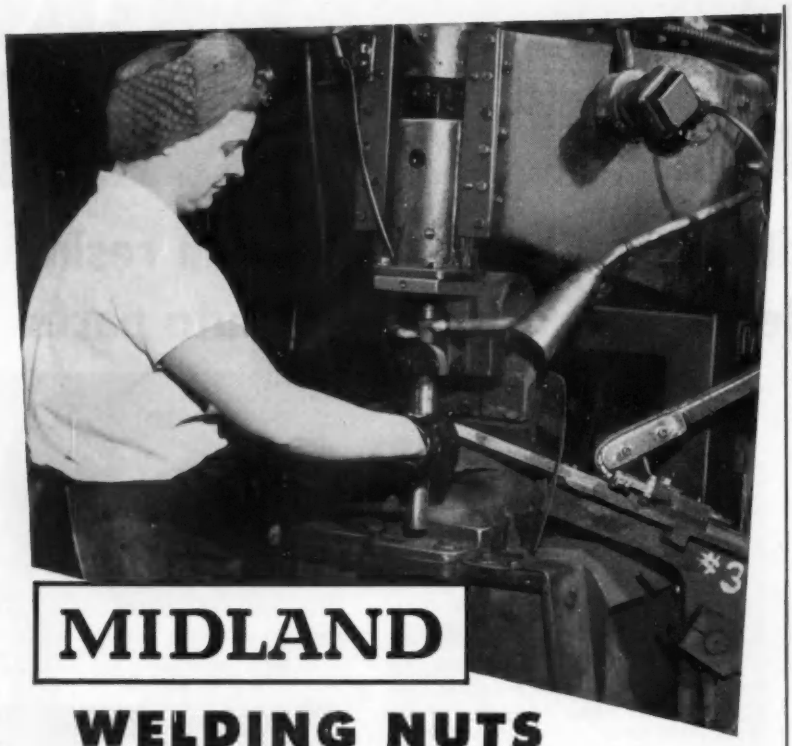

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a few years back. As a result of some excellent work by a CRC panel, a satisfactory fix was found and the overall oil quality was improved.

Other examples of excellent results of the partnership would be the case of the automatic transmission fluid and Caterpillar diesel-engine difficulties before World War II that led to the detergent oils.

There are still some areas in which the partnership must be termed a failure. For example, chassis lubrication should be extended safely beyond 1000 miles. Balance between oil and filter changes could be improved. Multipurpose greases haven't reached the performance quality hoped for.

The partnership will, however, continue to grow, and there will be better oils and better fuels available in the future.

GMOODIE—a New Low-Cost Die Material

Based on paper by

J. C. HOLZWARTH

and

S. MENTON

General Motors Corp.

GMOODIE is a new low-cost die material which helps to bridge the gap between the life expectancy of conventional base tools and that of expensive ferrous dies. Increased wear is achieved by alloying nickel and titanium to form hard intermetallics in the softer zinc-base matrix.

Fig. 1 shows the wear-resistant nickel-titanium particles embedded in the light-colored zinc-base matrix. The action of these particles in reducing attritious wear is similar to that of a carbide network in steel. While the embedded particles have considerable hardness (700–1000 diamond pyramid

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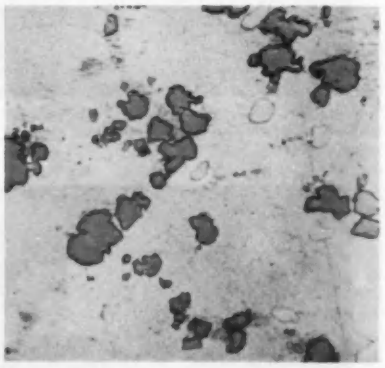
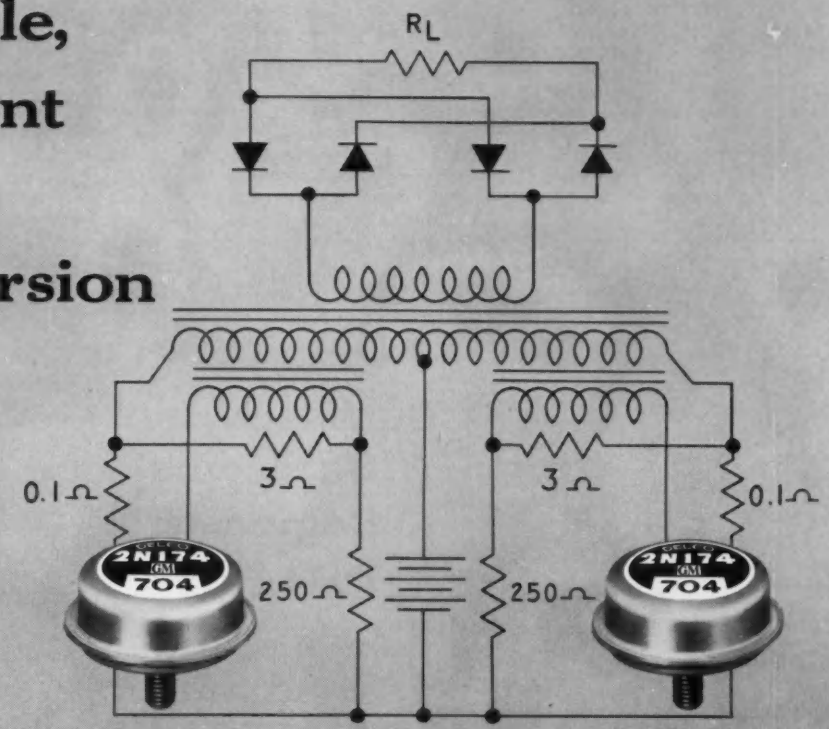


Fig. 1—GMOODIE is composed of wear resistant nickel-titanium particles embedded in a zinc-base matrix (light-colored background).

Reliable, Efficient DC Conversion



Industry's Highest Power Transistors

Low saturation voltage of Delco Radio 2N173 and 2N174 opens new opportunities for converter economy, efficiency and reliability

The excellent electrical characteristics of Delco High Power transistors permit the conversion of *low* DC voltage to *higher* DC voltage—with a high degree of efficiency—in a wide range of applications. This proved performance offers greater reliability than will be found in corresponding vibrator circuits.

The low saturation voltage of Delco 2N173 and 2N174 transistors also reduces their internal power dissipation in conversion applications to an insignificant degree so that little self-heating is apparent. The result is an overall economy which permits converters of smaller size . . . important in many applications.

TYPICAL CHARACTERISTICS

	2N173	2N174
Properties (25°C)	12 Volts	28 Volts
Maximum current	12	12
Maximum collector voltage	60	80
Saturation voltage (12 amp.)	0.7	0.7
Power gain (Class A, 10 watts)	38	38
Alpha cutoff frequency	0.4	0.4
Power dissipation	55	55
Thermal gradient from junction to mounting base	1.2°	1.2°
Distortion (Class A, 10 watts)	5%	5%

DELCO RADIO DIVISION OF GENERAL MOTORS KOKOMO, INDIANA

hardness), the overall hardness of the zinc-base alloy is only about 100–110 Bhn.

It has been found that GMOODIE, when used in drawing, forming, flanging, and bending dies, is capable of producing 5000–200,000 steel stampings, depending on the nature of the work. Stampings which have been formed include cold-rolled steel from 0.022 in. to 0.148 in. (24 to 9 gage), stainless steel in a variety of light gages, and aluminum from 0.022 in. to 0.060 in.

Experimental runs on steel as thick as ¼ in. have been made satsfactorily and 300–400 stampings from steel stock nearly ⅜ in. thick have been successfully produced. However, the largest production experience and the figures on which die performance is based are on 18–20 gage steel sheet. Where light-gage stock of this type is used, and the severity of the draw is moderate, GMOODIE will usually outwear conventional zinc-base tools by a factor of 4/1. However, as the gage size increases or as the severity of the drawing operation increases, the difference between the two zinc-base alloys will decrease somewhat.

The present market price of GMOODIE ingot is about 1.5–2 times the cost of conventional zinc-base die alloy. However, the material is more than 95% recoverable on remelting. If the cost of the original material can be regarded as capital investment and can be written off over a number of tools, the cost per die of this material is not substantially different than that of conventional zinc-base tools.

A number of studies have shown that zinc-base tools can be made at a cost of only 25–70% that of ferrous tooling. In addition, the time to get a die in operation is usually much shorter for the zinc-base tools. A medium-size GMOODIE tool has actually been put into operation with only five man-hours of handwork from the time the castings were removed from the mold to the point where it was producing usable castings.

While the 4/1 ratio of GMOODIE over conventional zinc-base tools will usually hold true for normal drawing operations on a moderate volume of parts, GMOODIE shows no advantage over conventional zinc-base tooling where very low volume (few hundred) of parts are required such as in prototype or die development programs. For these applications, the difference in material costs favors the use of conventional zinc-base alloy.

In designing dies of zinc-base alloy, experience has shown that sharp edges and small radii should be avoided wherever possible particularly on draw-die rings. Although GMOODIE has exceptional resistance to wear by rubbing or sliding of the sheet metal over its surface plastic flow of the die alloy will result where unit loading of the die surfaces is particularly high such as at sharp corners and radii or at locations where the sheet metal tends to gather or wrinkle. Wrinkles can do much damage to a zinc-alloy die. Where wrinking is unavoidable steel inserts may be considered or a stronger material may be necessary.

Sheet steel for production on GMOODIE and other zinc-base tools requires more careful preparation than for hard dies. The edges should be free from shearing burrs, since these tend to tear or scratch the soft zinc-base matrix. Extraneous dirt must be removed since this is even more injurious to zinc dies than hard dies. Finally, a good lubricant should be used on nearly every sheet. Flake graphite has been found to prolong the life of dies, particularly during initial break in period of the first 100 blanks.

(Paper, "Wear-Resistant Low-Cost Sheet Metal Forming Dies" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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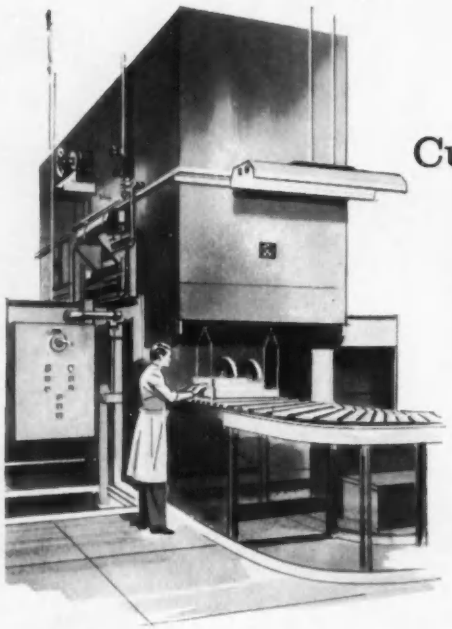

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Pictured above is the new Curtiss-Wright Degreaser DB4-60 which cleans and degreases 95% of the precision parts of a Curtiss-Wright Turbo-Compound aircraft engine prior to assembly. Where formerly this operation took hours, these parts are now cleaned in minutes – and cleaned more thoroughly.

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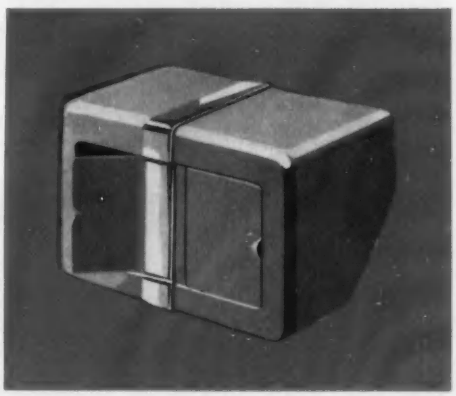

Ride Measurement Needs New Parameters

Based on paper by

J. J. McDONALD
Consolidated Electrodynamics Corp.

ALTHOUGH instrumentation can be designed for objective measurement of ride characteristics, new parameters are needed which will take into account the many subjective physiological and psychological aspects involved in the ride problem.

The measurement of car-ride characteristics would seem to be in the direction of the development of a transducer having frequency response, damping, mass, similar number of degrees of freedom, size and amplitude sensitivity similar to some average human body. Such a transducer, combined with a suitable compatible system of electronics which would be designed to give the proper presentation of data as required by the project engineer, would appear to solve the problem.

However, it is not that simple. In the first place, if such a transducer could be designed, it would represent only the objective characteristics required in the design parameter of the transducer. As we are all aware, there are many subjective physiological and psychological aspects involved in the ride problem.

In the second place, the optimum design would be for some hypothetical average individual and would be less than optimum for every other. The amount of deviation of course equals the extent of deviation of the selected individual as compared to the average.

This does not mean that ride measurement tests are futile. Tests of this type have been conducted extensively in the past, and for certain design considerations can be interpreted successfully. However, when attempts are made to relate this data to subjective information the results are very difficult to correlate, and are discouraging.

As a result of this absence of definite design criteria, there has been designed a wide variety of ride-measurement instrumentation, each of which covers some phase of the field very adequately from an objective point of view. However, as mentioned, this is only part of the problem.

To really solve the problem, what is needed are some very realistic parameters of ride. The manufacturer would then be in a position to relate this data to his standard product design and be in a position to implement test programs with satisfactory instrumentation which would be economically feasible to use over a broad field.

(Paper, "Passenger Ride and Comfort Measurements as Seen by the Manufacturers," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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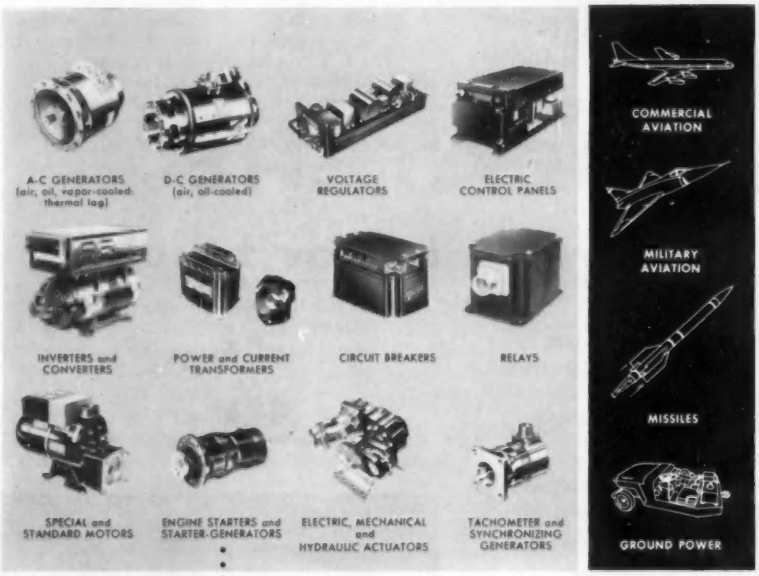

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For Economy, Match Engine to Installation

Based on paper by

F. W. SINKS
Detroit Diesel Engine Division, General Motors Corp.

A DIESEL engine should be matched properly to the application if the best fuel economy is to be had. Some ground rules which may prove helpful to the equipment designer in selecting a good engine-power train combination are:

1. Use the transmission and axle combination that allows the engine to operate as closely as practicable to its most efficient speed.

2. Plan the installation to give a minimum differential between ambient air and the engine intake air temperature and use thermostatically con-

Continued on page 125

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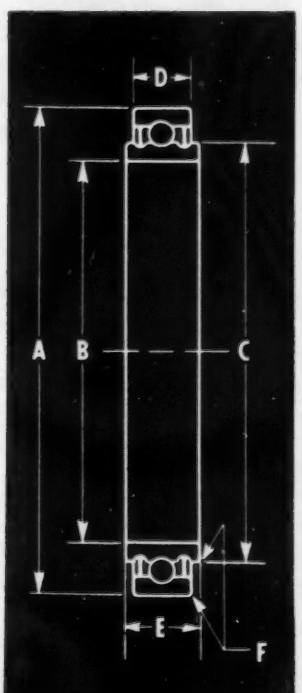
. . . the thinnest shielded, precision ball bearing made

Only the simplest type of housing is required for the Fafnir B500DD ball bearing because it's fully protected against contaminants. This results in lower design and manufacturing costs. In addition, the B500DD conserves space, keeps weight down to a minimum.

In the table below are the sizes and weights of the B500DD bearing. Look them over. Perhaps you'll find an answer here to a bearing problem. Complete information, including load ratings, on request. Write The Fafnir Bearing Company, New Britain, Connecticut.

DIMENSIONS (inches)

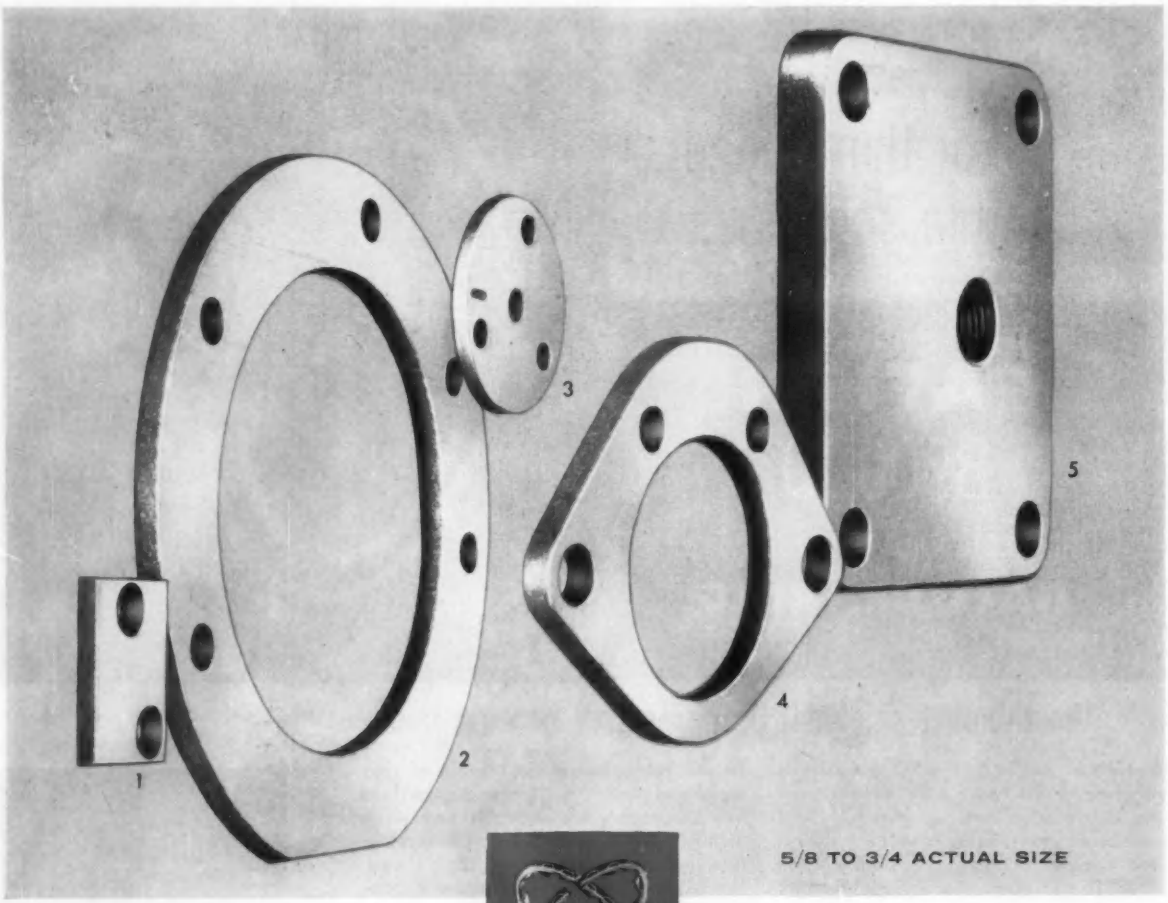
BEARING NO.	A Outside Diameter +.0000 −.0010	B Bore +.0007 −.0007	C Outside Diameter Inner Ring (approx.)	D Width Outer Ring +.000 −.005	E Width Inner Ring +.000 −.005	F Corner Radii‡	BALLS No.	BALLS Size	Weight Pounds (approx.)
B538DD	1.0625	.6250	.777	.250	.281	.015	21	1/8	.03
B539DD	1.1875	.7500	.895	.250	.281	.015	24	1/8	.04
B540DD	1.3125	.8750	1.016	.250	.281	.015	27	1/8	.05
B541DD	1.5000	1.0625	1.216	.250	.281	.015	32	1/8	.06
B542DD	1.7500	1.3125	1.451	.250	.281	.015	38	1/8	.09
B543DD	2.0000	1.5625	1.702	.250	.281	.015	44	1/8	.10
B544DD	2.2500†	1.8125*	1.970	.250	.281	.015	51	1/8	.11
B545DD	2.6250†	2.0625*	2.286	.250	.281	.015	59	1/8	.15
B546DD	2.8750†	2.3125*	2.527	.250	.281	.015	65	1/8	.17

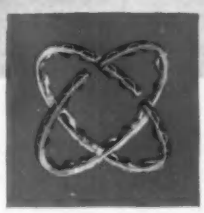


* +.0010 −.0010 † +.0000 −.0015 ‡ Maximum shaft or housing fillet radius which bearing corners will clear

FAFNIR AIRCRAFT BEARINGS

FIRST . . . at the turning points in aircraft design



From the producer of piston rings  used in 1 out of every 3 new cars . . .

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4) Choice of any metal, including latest sintered powdered metals.

(1) Automatic transmission governor cover plate.
(2) Countershaft retaining ring.
(3) Compressor thrust plate.
(4) Camshaft attaching plate.
(5) Oil filler cover.

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Here's an assortment of miniature iron and bronze sand castings and sintered powdered metal parts that shows how Sparta can reduce or completely eliminate your finishing and machining operation. Write Sparta Foundry Co., Sparta, Mich.

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ROTARY SEAL DIVISION PLANTS AT SPARTA, MICHIGAN CHICAGO, ILLINOIS

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trolled cooling fans to reduce parasitic losses.

3. Consider the use of variable displacement pumps, open center systems, and mechanical disconnects to reduce the power losses incurred by hydraulic pumps when unloaded.

4. Choose accessories carefully to reduce power train losses.

5. Use an engine which has sufficient power to operate at its designated conditions, but not so much excess power that the operator can "hot rod" and burn fuel with a minimum of overall work done.

(Paper, "Matching the Engine to the Application," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Designing Trucks For Driver Comfort

Based on paper by

A. C. MAIR
General Motors Corp.

TO produce a truck which has a stable feel to its occupants, the designer should aim for:

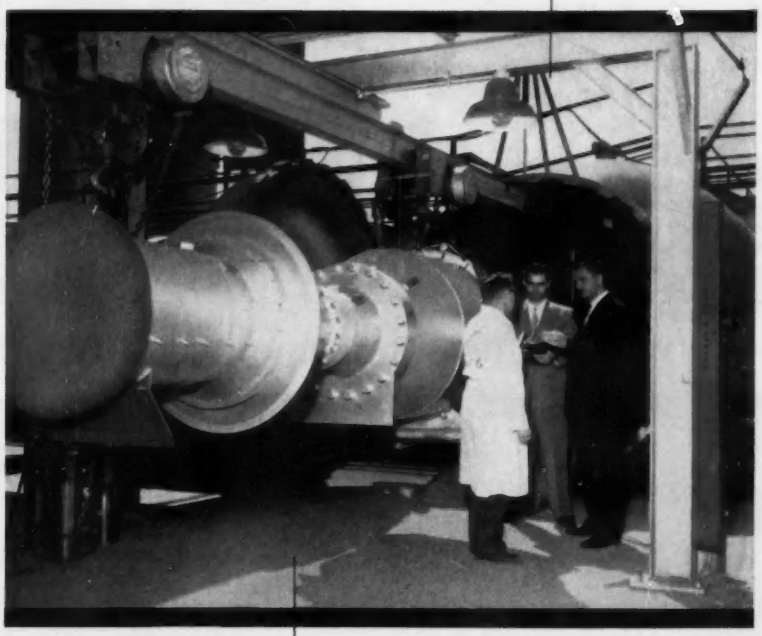
1. Truck configurations which do not load the rear tires more than the front at full load.
2. A front and rear roll couple so distributed that from empty to loaded the rear tires do not lose more cornering power than do the front.
3. A wheelbase as long as absolutely possible compared with the total length of the truck and still comply with No. 1. (This will keep the yaw stability high.)
4. Avoidance of excessive rear-suspension understeer getting as near neutral as possible.

A truck so designed will tend to be self-correcting in direction when disturbed by wind gusts or changes in road camber. It will give the driver prompt and definite indication of changes in course by torque responses at the steering wheel. It will respond accurately to driver corrections without overshooting the desired mark. It will, in short, probably be a "good handling truck."

(The conclusions mentioned above are based on tests which are described completely in the paper "Road Behavior of a Modern Truck." This paper is available from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

Continued on page 126

Test Engineers



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Marquardt offers outstanding opportunities in supersonic propulsion

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At Marquardt, outstanding opportunities exist for personnel with a degree in Mechanical, Aeronautical, Electrical, Civil or Chemical Engineering; or with specialized training and experience in test facility design, operations, instrumentation and analysis.

Professional Engineers interested in becoming a name instead of a number, are invited to contact Jim Dale, Professional Personnel, Marquardt Aircraft Co., 16554 Saticoy Street, Van Nuys, California.

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FIRST IN RAMJETS
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Better Mufflers Cure Truck Noise

Based on paper by

W. A. BONVALLET
General Motors Proving Ground

CONTROL of truck noise has emerged from its period of faltering progress. A measuring method has been developed. We are now faced with the problem of equipping the older trucks on the road in line with their newer companions.

A relatively small percentage of trucks are using the "premium" mufflers necessary to meet the new-vehicle design standard of 125 sones set by an Automobile Manufacturers Association committee in 1954.

Over-the-counter sales of replacement mufflers for two truck manufacturers from January '55 through June '56, for example, shows sales of old-type to "premium" type mufflers running 3½ to 1 in one case; 45 to 1 in the other.

Self-policing by the truck manufacturing and operating industries is the best remedial action that can be taken.

(Paper "The Ins and Outs of Motor Truck Noise" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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...Vernatherm® controls assure correct operating temperature for these BIG Diesel Machines

Here is your answer to tough coolant problems on Diesel and heavy-duty gasoline engines . . . Detroit Controls Vernatherm . . . a solid-charged thermostat that will take all the punishment big engines and rough duty can give it, and still give positive, precise coolant control *indefinitely.*

Pioneered by the Detroit Controls Corporation, these Vernatherm thermostats have a reputation for solving knotty problems in the roughest kinds of service.

Call on a Detroit sales engineer for application assistance . . . or write for Bulletin 213, which gives basic data on Vernatherm Controls and their function in modern engine design.

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New Pressure-Volume Measure Advantageous

Based on paper by

R. E. GISH, J. D. McCULLOUGH, J. B. RETZLOFF, and H. T. MUELLER
Ethyl Corp.

USING a statistical technique for measuring pressure-volume relations in a firing cylinder has shown advantages for high compression ratio engines not indicated by the common motoring method.

The peak pressure for many cycles is recorded and a distribution curve constructed. From the curve the average pressure is measured. This is continued for other pressures at different crank angles, giving a complete p-v diagram. This diagram is not subject to the usual eccentric pressure reading found with indicator card readings,

Continued on page 128

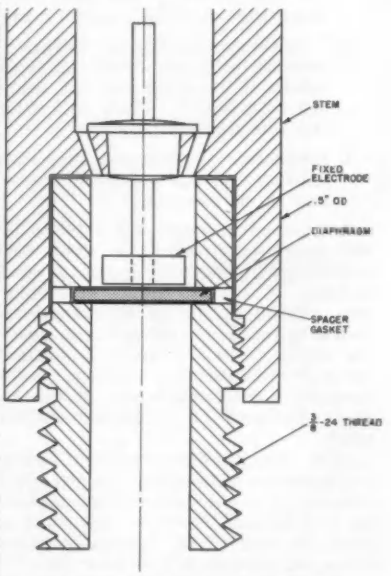
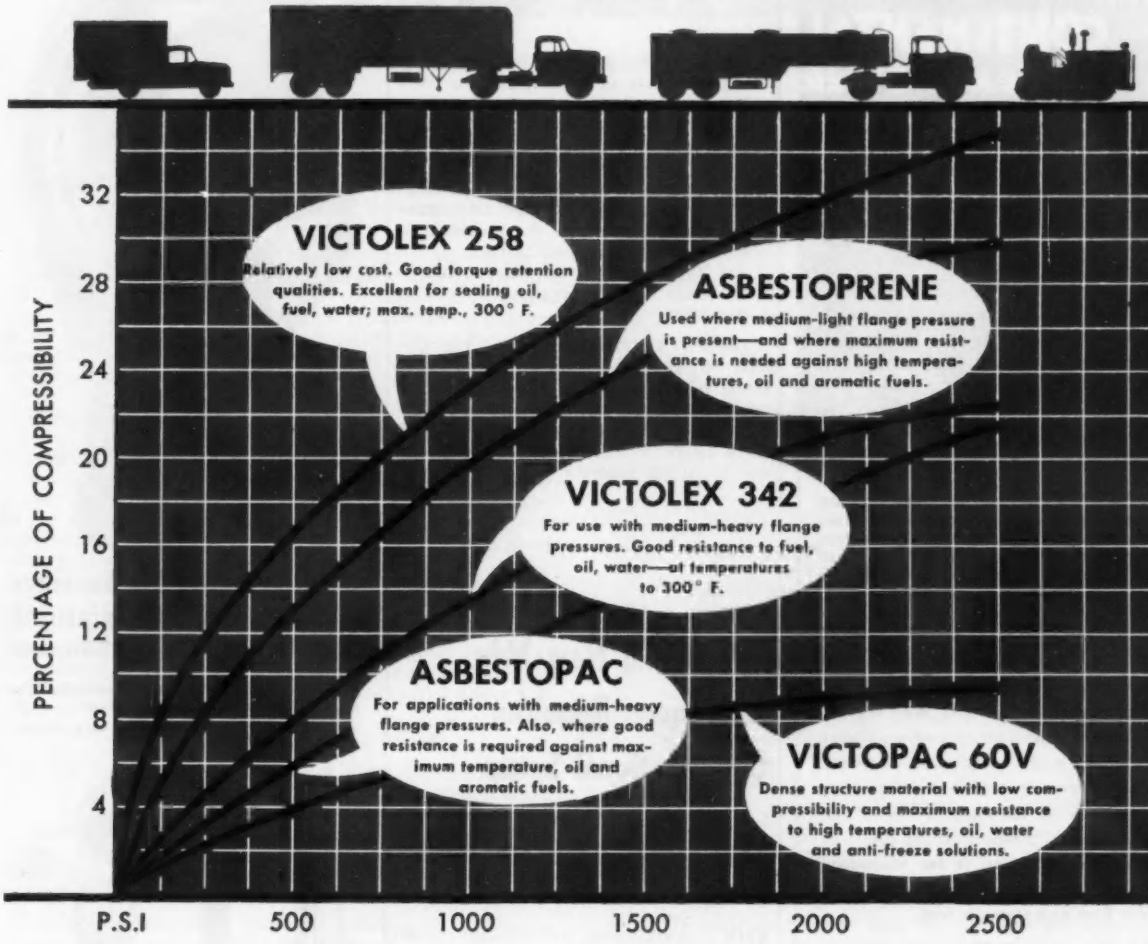


Fig. 1—Balanced-pressure indicator.

VICTOR

"Soft" PACKINGS FOR HEAVY-DUTY INDUSTRIES


PERCENTAGE OF COMPRESSIBILITY
32
28
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12
8
4
VICTOLEX 258
Relatively low cost. Good torque retention qualities. Excellent for sealing oil, fuel, water; max. temp., 300° F.
ASBESTOPRENE
Used where medium-light flange pressure is present—and where maximum resistance is needed against high temperatures, oil and aromatic fuels.
VICTOLEX 342
For use with medium-heavy flange pressures. Good resistance to fuel, oil, water—at temperatures to 300° F.
ASBESTOPAC
For applications with medium-heavy flange pressures. Also, where good resistance is required against maximum temperature, oil and aromatic fuels.
VICTOPAC 60V
Dense structure material with low compressibility and maximum resistance to high temperatures, oil, water and anti-freeze solutions.
P.S.I
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1000
1500
2000
2500

Full range of synthetic packings

The five Victor "soft" packings plotted on the comparative compressibility chart answer many problems for automotive sealing engineers. Each packing is made of the best materials for coping with problems inherent in specific applications. Each has the right density and degree of compressibility to meet varying flange pressures, temperatures and the penetration of water, oils and other fluids. Each packing conforms to SAE-ASTM specifications.

Complete technical information about these packings and their uses is available from your Victor Field Engineer. If you do not know where to reach him, write Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.

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HIGH efficiency
LOW COST...
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CRAWLER-MOUNTED BACK-HOE
with
CONTINENTAL
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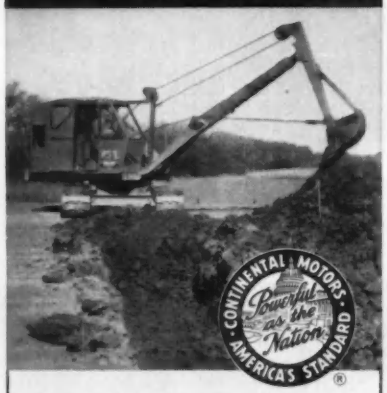

C-35 Crawler Bantam's long reach enables the operator to spot overburden away from the trench, while the new narrow design of Bantam's gooseneck boom improves visibility, speeding the work. Built by Schield Bantam Co., Waverly, Iowa. Engine: Continental Red Seal F-186.

●

Famous Schield Bantam equipment is another notable example of the fine results to be achieved by tailoring the engine to its job. With Schield Bantam, as with other leading makes of power equipment, each Red Seal used has been engineered and built expressly for its work. Whatever the machine . . . whatever its job . . . you can bank on it for abundant power at the speeds consistent with low fuel and upkeep cost.

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WORLD'S LEADING INDEPENDENT MANUFACTURER OF INTERNAL COMBUSTION ENGINES, CONTINENTAL MOTORS OPERATES PLANTS IN ATLANTA, DALLAS, DETROIT, MILWAUKEE, MUSKEGON, AND TOLEDO, AND IN ST. THOMAS, ONT., PRODUCING AIR-COOLED AND LIQUID-COOLED ENGINES FOR USE ON LAND, AT SEA AND IN THE AIR.

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Continental Motors Corporation
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where one or several cycles are used to determine indicated horsepower.

Accurate pressure measurements are obtained by using a free-floating diaphragm balanced by a carefully controlled reference pressure. (See Fig. 1.) The reference pressure is varied to cover the fluctuations in cylinder pressure at a given crank angle.

Tests on a 6-cyl engine with two heads, one 7/1 and the other 12/1 compression ratio, showed the following:

- Attainment of constant mechanical efficiency over ratio ranges from 7/1 to 12/1.
- Percentage improvements in thermal efficiency greater than these of the ideal air cycle.
- Improvements in brake thermal efficiency equal to those in engine thermal efficiency—if mechanical efficiency can be maintained.
- A limiting ratio for improvements in brake power significantly higher than 12/1.

(Paper "Determination of True Engine Friction," on which this abridgement is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price 35¢ to members; 60¢ to nonmembers.)

Developing New Mfg. Techniques Requires Organizational Setup

Based on secretary's report by

B. R. ALSOBROOK

Rohr Aircraft Corp.

THE responsibility of setting up an organization to develop a particular manufacturing and processing technique must rest with one group; however, all groups must be kept informed.

The monitor of these research and development projects may come from any group. If it is primarily an engineering endeavor then possibly the monitor would be a representative of one of the engineering divisions. Should the subject be more closely allied with manufacturing the monitor would probably be from the manufacturing research department or the manufacturing area most closely allied to the program. North American uses the production laboratories of the quality control department as its monitor.

Whatever group has this responsibility monitors the program on the basis of a project letter which has been

Continued on page 130

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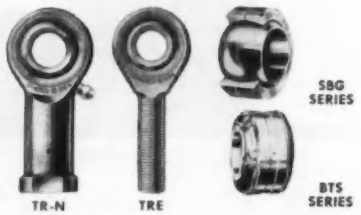

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NEW GOLDEN BONDERITE

How its golden color can mean better products, greater profits for aluminum fabricators

The golden coating achieved on aluminum by new Golden Bonderite is the key to a whole new concept in control, economy and efficiency.

No longer need you worry along with variations in coating weights and solution analyses that go up and down from hour to hour or day to day. The color of the metal as it emerges from the Bonderite machine is a visual check on solution effectiveness and coating quality. It looks the same—and it is the same—24 hours a day, seven days a week.

Parker "Reactifier" and How It Works

In ordinary surface treatment solutions of this kind, a build-up of impurities occurs as work is processed. These impurities affect the efficiency of the treatment in inverse ratio until finally the solution is beyond redeeming. The tank has to be dumped and a fresh bath made up.

This costly, wasteful procedure is ended when you use Golden Bonderite in conjunction with the sensational Parker "Reactifier" column, an exclusive apparatus that polices the solution constantly, removing the harmful elements and allowing you to use the solution indefinitely, without ever having to discard it.

Better Products, Better Profit

You use a surface treatment for your aluminum production to improve paint adhesion and corrosion resistance, to reduce rejects in the finishing department and to assure customer satisfaction. Uneven efficiency in surface treatment usually means loss of paint adhesion, production rejects and the danger of costly field service and replacements.

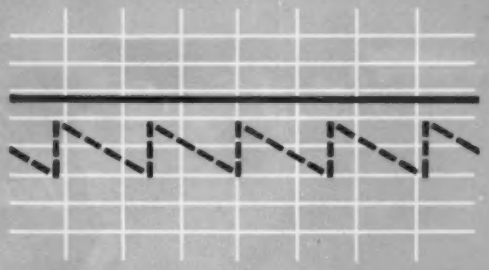
Golden Bonderite's uniform efficiency, so easily checked by color, will save you money.

1 It provides a uniform, effective paint base.

2 It allows you to schedule and maintain high production levels.

3 It permits operation at uniform low chemical concentrations.

4 It eliminates the need for dumping and rebuilding treatment solution.



Straight-as-a-string solution analysis

The saw-tooth line above is entirely too familiar to operators of conventional aluminum treatments. Efficiency sags as metal is treated, recovers as chemical is added, quickly sags again in use. Quality is uneven and uncertain.

New Golden Bonderite and the amazing new "Reactifier", developed by Parker, bring "straight-as-a-string" efficiency. No variation in quality even if you operate 24 hours a day, seven days a week. Solution analysis remains constant, free of impurities that reduce efficiency and quality.

Simple To Use

New Golden Bonderite may be applied by spray or immersion. Treatment time can be varied to suit production speeds and equipment. Golden Bonderite comes to you in concentrated liquid form, easy to handle and use.

Let us show you actual samples and test data on Golden Bonderite for aluminum. Call or write today!

NOTE: *A companion product to Golden Bonderite produces an appealing scratch-resistant green coating on aluminum. It's a lovely color without further finishing. A natural for architectural products.*

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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

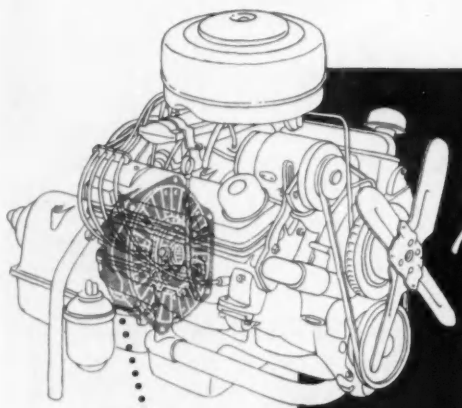
**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

written and approved by all departments concerned. This project letter defines, in fairly broad terms, the area of participation by each group that has been assigned a part of the development program.

All groups are notified of their part in the project and through a series of meetings are made aware of the problems involved in their particular phase of the activity.

The success or failure of any particular project depends primarily on the degree of coordination achieved between participants. There can be very little leeway granted in overlapping of function or areas of activity. With the tremendous cost and effort involved in many of these projects any laxity in administration, breakdown of communications, or failure to follow the programmed procedure may result in failure of the complete effort. It is therefore necessary that coordination and exchange of progress reports between all groups concerned be frequent, factual, and cooperative.

(The report on which this article is based, together with 14 other aircraft production panel reports, is available in full as SP-317 from SAE Special Publications, 485 Lexington Avenue, New York 17, N.Y. Price: $2 to members; $4 to nonmembers.)



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DIVISION OF BORG-WARNER

Chicago 38, Illinois

High-Vanadium Die Steel Developed

Based on paper by

PAUL R. BORNEMAN

Allegheny Ludlum Steel Corp.

RESISTANCE to galling and seizure in deep drawing operations features Ottawa 60, a new die steel with high vanadium content. These desirable properties are obtained by having a high proportion of the vanadium carbide in the steel microstructure.

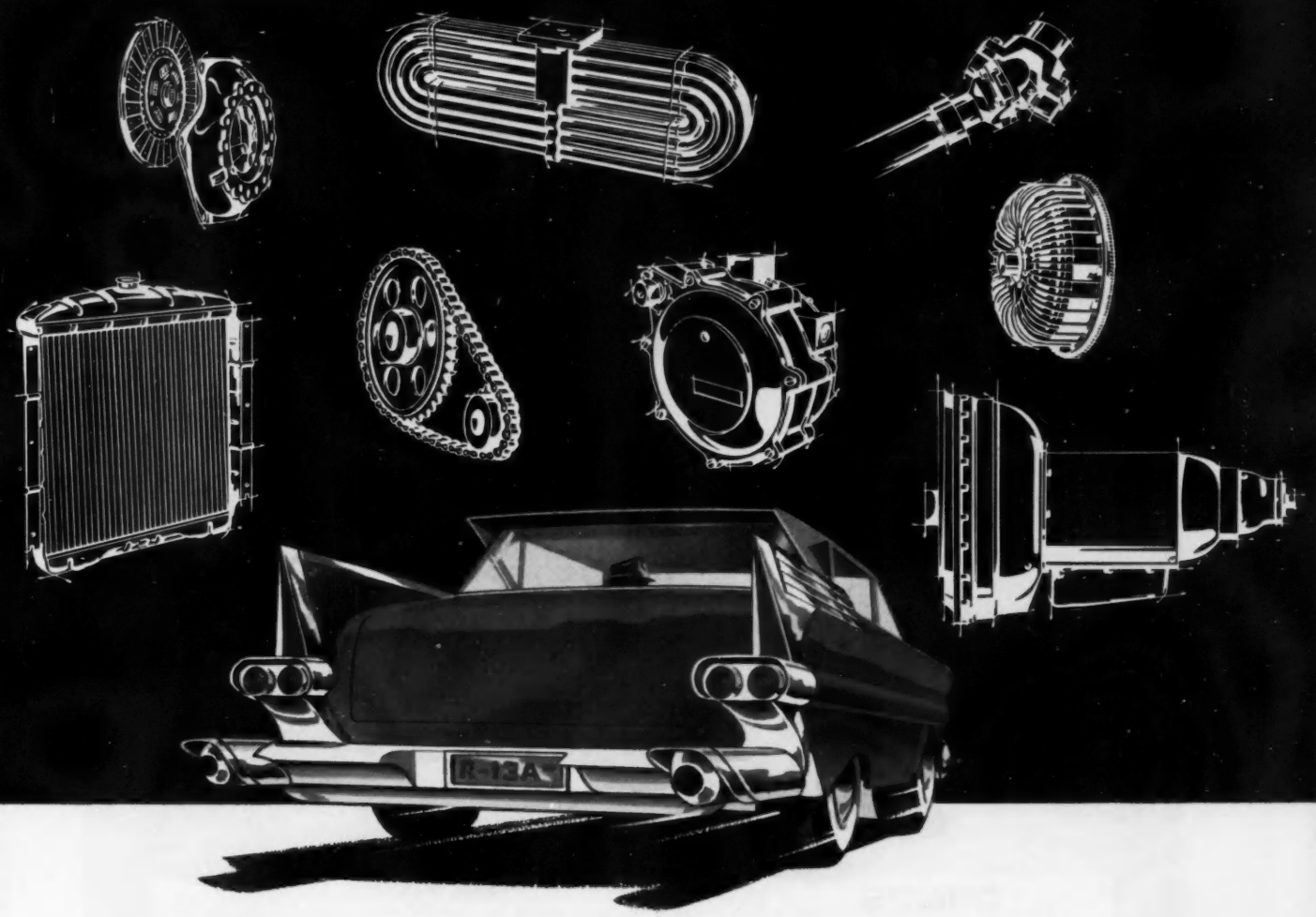
In the development of this steel it was reasoned that galling and seizure were caused by smearing of the matrix portion of the microstructure and that to produce a material with higher resistance to galling a large proportion of carbide must be produced in the microstructure. Vanadium carbide was selected because of its high inherent hardness.

Ottawa 60, as the new steel is termed, contains approximately 12% vanadium, 3.25% carbon, 1% chromium and 1% molybdenum. Chromium molybdenum were added to increase hardenability to the point where the steel would air harden in sections under 3 in. in diameter. The steel hardens to about 65 Rockwell C after quenching from a temperature range of 1750–1800 F.

The steel's behavior in heat-treatment is similar to high-carbon high-chromium die steels, requiring long soaking times at temperature, therefore, pack hardening is recommended. Because of the high affinity of vanadium for carbon, the matrix structure is somewhat lean in carbon and the steel is more subject to carburization than decarburization. For this reason, a packing medium containing little or no carbonaceous material, such as spent pitch coke or plain sand, should be used.

The steel is slightly more difficult to machine, but turning, facing, boring, and drilling can be done with normal tooling at somewhat reduced speeds. It is almost impossible to saw on power machines, but sawing can be done on a power hack saw using a coarse saw blade with a maximum of four teeth per inch. Finish grinding in the hardened state is also difficult. On a scale

Continued on page 135



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Automatic, overdrive and standard transmissions, torque converters, clutches, radiators, oil coolers, gears, timing chains, universal joints and drive shafts, synchronizers, carburetors, parking brakes . . . each of these and other vital B-W components prove Borg-Warner's ability to "design it better—make it better"—the B-W challenge that compels continuing progress.

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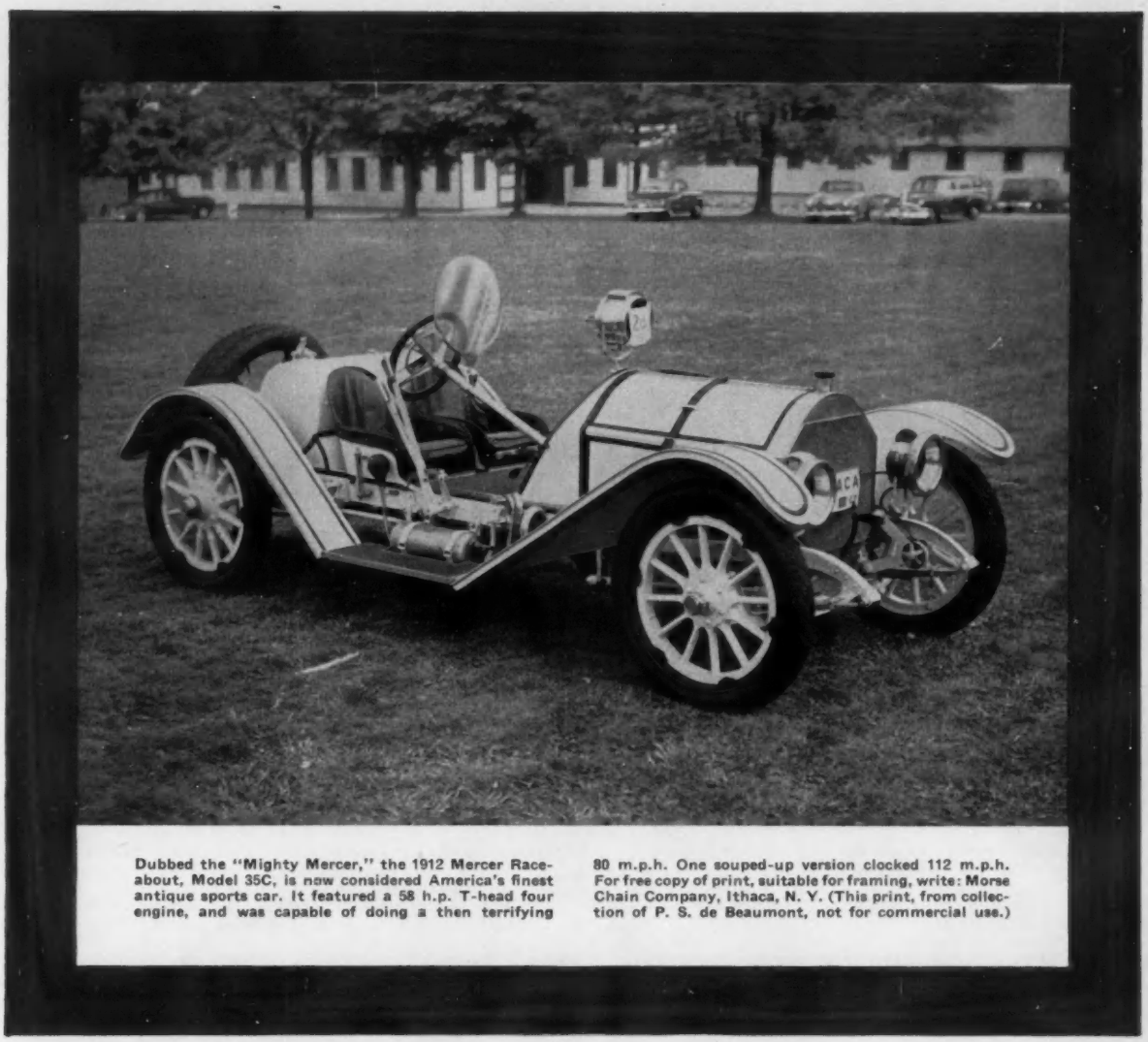

Dubbed the "Mighty Mercer," the 1912 Mercer Raceabout, Model 35C, is now considered America's finest antique sports car. It featured a 58 h.p. T-head four engine, and was capable of doing a then terrifying 80 m.p.h. One souped-up version clocked 112 m.p.h. For free copy of print, suitable for framing, write: Morse Chain Company, Ithaca, N. Y. (This print, from collection of P. S. de Beaumont, not for commercial use.)

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INGERSOLL STEEL—automotive and tractor clutch discs; carbon electric steel for tank clutch plates; high carbon and alloy steel sheets; stainless and stainless-clad sheets and armor plate.

LONG MANUFACTURING—clutches and radiators for passenger cars, trucks, buses and tractors; torque converters; oil coolers for the automotive industry; automotive stampings; truck, tractor and bus transmissions; tractor axles and hydraulic pumps; gears and precision parts.

LONG MANUFACTURING CO., LTD. (Canada)—clutches and radiators for passenger cars, trucks, buses and tractors; oil coolers for the automotive industry.

MARBON CHEMICAL—adhesives for bonding rubber and synthetic rubber to metal and other materials; high impact thermoplastic resins.

MARVEL-SCHEBLER PRODUCTS—carburetors for military and industrial equipment and farm tractors; LPG carburetion systems; automatic transmissions.

MECHANICS UNIVERSAL JOINT—universal joints and propeller shafts for passenger cars, trucks, buses, aircraft, farm machinery, tractors, road machinery and mining machinery.

MORSE CHAIN CO.—automotive timing chains and sprockets.

MORSE CHAIN OF CANADA, LTD.—automotive timing chains and sprockets.

PESCO PRODUCTS—electric driven and engine driven hydraulic pumps; valves and electric motors for agricultural and industrial use.

ROCKFORD CLUTCH—spring-loaded and over-center clutches for automobiles, trucks, tractors, road-building, earth-moving and oil field machinery, industrial machinery, agricultural implements, machine tools (Pullmore). Power take-off and gear reduction units for gasoline and diesel engines.

SPRING DIVISION—torque converter parts and sub-assemblies; sprag type free wheeling clutches; special clutch plates and parts for automatic transmissions; precision flat and Belleville type springs; multislide and punch press stampings, plain and heat treated; special commercial heat treating; small electric motor commutators.

WARNER AUTOMOTIVE PARTS—for replacement purposes—ring gears and pinions; differential cases; differential internal gears and spiders; axle shafts; cast iron parts; transmission gears for passenger cars, trucks, tractors.

WARNER GEAR—automotive transmissions, overdrives, automatic transmissions, synchronizer assemblies, parking brakes, automotive and aircraft gears.

WARNER GEAR CO., LTD. (Canada)—synchronizer units for passenger cars and trucks.

YORK—refrigeration for trucks.

ENGINEERING B-W PRODUCTION

BORG-WARNER CORPORATION

310 S. MICHIGAN AVE., CHICAGO 4, ILLINOIS

in which carbon steel is rated at 40, the grindability of Ottawa 60 is 0.4. Suggestions for grinding are to use a wheel with a free-cutting bond which will present new cutting edges to the work on each revolution, grind at slower than normal speeds, and employ diamond wheels.

(Paper "Development of a Modern High Vanadium Die Steel" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

operated successfully under the rigorous requirements of the high-performance 1958 models.

For several years past, in fact, various companies have been experimenting at length to get an even further reduction in ratio of section height to width. One U. S. tire has an 85% ratio of section height to width. It has been used extensively by car manufacturers in high-speed testing work.

Tests and experience with this tire revealed no basic structural problems, but did show need for refinements in ride characteristics such as hardness and harshness. These were resolved by minor modifications.

Tires, smaller in size even than at present, are on the horizon.

(Paper "Low Profile Passenger Car Tires," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Low Profile Tires May Be Needed for Cars

Based on paper by

J. G. BERRY
U. S. Rubber Co.

A TIRE section shape having a ratio of section height to section width less than unity has the best chance of meeting the increasingly difficult conditions under which car tires must operate. Experience with such tires in aircraft, off-the-road vehicles, farm tractors indicates they can face successfully the passenger cars needs ahead. These needs include:

1. For clearance, the tire must be smaller in diameter to carry a load equal to present tires.

2. For adequate brakes, the rim diameter must be no smaller than at present.

3. For ride, inflation pressures must be of the same order (or less) than those now used.

4. For handling ease, stability must be improved.

5. For greater economy and improved efficiency, the power consumption must be improved.

6. For safety, tires must have durability for use at high speeds, as well as against general use and abuse.

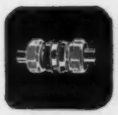
Some passenger-car experience already exists with these tires whose ratio of section height to width is less than unity. ("Low profile" is the term generally being applied to them.)

When the 14-in. tire was introduced, for example, the section-height to section-width ratio was dropped to 90–92% to produce the lowest loaded radius possible, compatible with the knowledge of passenger-car tire design at that time . . . and these tires have

ROCKFORD
MORLIFE® Over-Center CLUTCHES Provide

HIGH TORQUE

Small Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Speed Reducers
ROCKFORD Over-Center CLUTCHES, equipped with MORLIFE clutch plates, provide 100% more torque grip than previous type clutches of equal size. This permits the use of smaller diameter clutches. Easier operation is accomplished by reducing the required engaging pressure. 50% better heat disposal avoids down-time caused by burned or warped plates. Numerous field records prove that MORLIFE clutches operate 400% longer without plate replacement or adjustment. Let these NEW type clutches help improve the operation of your heavy-duty machines.
SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.
ROCKFORD Clutch Division BORG-WARNER
316 Catherine St., Rockford, Ill., U.S.A.
Expert Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.
CLUTCHES

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*TEFLON is a registered DuPont trademark.
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SF 212 DOUBLE WIRE BRAID HOSE with SF 320 REUSABLE SWIVEL FITTING for high pressure applications. Working pressure range: 1,125 to 5,000 psi.
SF 211 SINGLE WIRE BRAID HOSE with SF 319 REUSABLE SWIVEL FITTING for medium pressure applications. Working pressure range: 350 to 2,000 psi.
SF 124 TEFLON HOSE with SF 524, SWAGED FITTING for aircraft applications. Stays flexible from −100° to +450° F. Unaffected by all fuels, petroleum, synthetic base lubricants, acids, and solvents.
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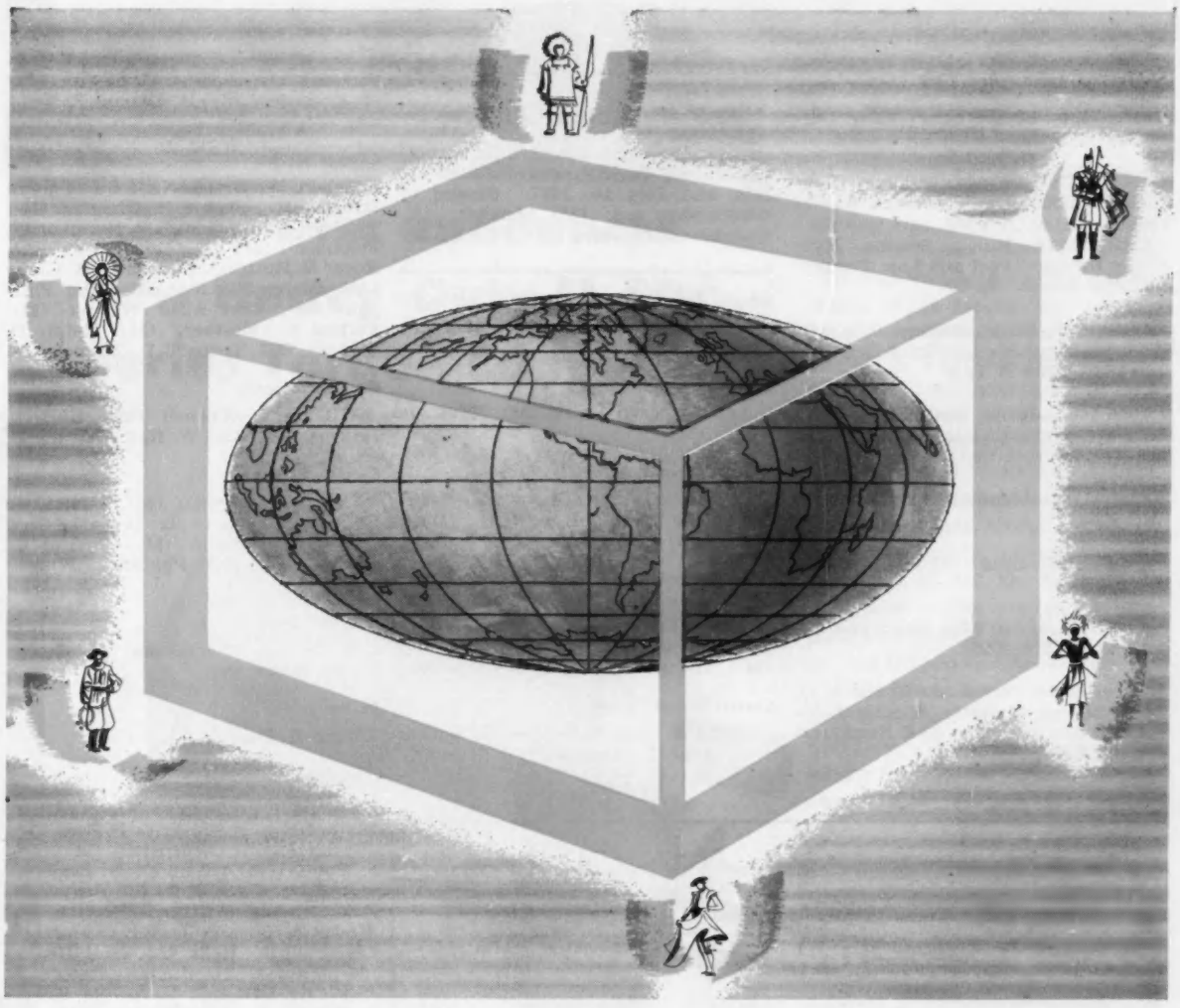
AMS continued from page 85

—4V, Annealed—120,000 psi Yield

- AMS 4921A—Titanium, Annealed—70,000 psi Yield
- AMS 4925A—Titanium Alloy, 4Al-4Mn, Annealed—130,000 psi Yield
- AMS 4928—Titanium Alloy, 6Al-4V, Annealed—120,000 psi Yield
- AMS 5334A—Steel Castings, Precision Investment, 0.5Cr-0.55Ni-0.2Mo (0.25–0.35C)
- AMS 5336—Steel Castings, Precision Investment, 0.95Cr-0.2Mo (0.25–0.35C)
- AMS 5338—Steel Castings, Precision Investment, 0.95Cr-0.2Mo (0.35–0.45C)
- AMS 5540E—Alloy Sheet and Strip, Corrosion and Heat Resistant—Nickel Base 15.5Cr-8Fe
- AMS 5541—Alloy Sheet, Corrosion and Heat Resistant—Nickel Base—15.5Cr-7Fe 2.5Ti-0.7Al
- AMS 5542E—Alloy Sheet, Corrosion and Heat Resistant—Nickel Base—15.5Cr-7Fe 2.5Ti-1(Cb + Ta)-0.7Al
- AMS 5556A—Steel Tubing, Corrosion and Heat Resistant—18Cr-11Ni-(Cb + Ta) (SAE 30347)—Hydraulic
- AMS 5557A—Steel Tubing, Corrosion and Heat Resistant — 18Cr-11Ni-Ti (SAE 30321)—Hydraulic
- AMS 5616C—Steel, Corrosion and Moderate Heat Resistant—13Cr-2Ni-3W
- AMS 5632B—Steel, Corrosion Resistant, 17Cr-0.5Mo (0.95–1.20C) (SAE 51440F)—Free Machining
- AMS 5673A—Steel Wire, Corrosion Resistant, 17Cr-7Ni-1Al, Precipitation Hardening—Spring Temper
- AMS 5679A—Alloy Wire, Corrosion and Heat Resistant—Nickel Base—15.5Cr-8Fe 2(Cb + Ta), Cold Drawn
- AMS 5687C—Alloy Wire, Corrosion and Heat Resistant—Nickel Base—15.5Cr-8Fe Annealed
- AMS 5778—Alloy Wire, Corrosion and Heat Resistant—Nickel Base—15.5Cr-2.4Ti 1(Cb + Ta)-0.7Al-7Fe
- AMS 7205A—Spring Pins—Tubular—Steel
- AMS 7228C—Rivets, Steel, Corrosion Resistant—18Cr-8Ni
- AMS 7229B—Rivets, Steel, Corrosion and Heat Resistant—18Cr-11Ni-(Cb + Ta)
- AMS 7232D—Rivets, Alloy, Corrosion and Heat Resistant—Nickel Base—15.5Cr-8Fe
- AMS 7233—Rivets, Solid, Alloy, Corrosion Resistant—67Ni-30Cu

Continued on page 138



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Shell Dromus Oil—cutting oils for high-production metalworking

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Rimula Oil is a heavy-duty oil designed to solve the toughest lubricating problems in diesel engines.

Rimula® Oil reduces cylinder and bearing wear caused by acidic combustion products that are increased by low jacket temperatures. It remains stable under the widest temperature extremes encountered in modern operation. It keeps engine parts clean and operating efficiently over longer periods...effecting worth-while savings in labor and parts.

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SHELL RIMULA OIL

SHELL

continued from page 136

- AMS 7234—Rivets, Blind, Alloy, Corrosion Resistant—67Ni-30Cu-0.04S

- AMS 7270D—Rings, Sealing, Synthetic Rubber—Fuel Resistant (65–75)

- AMS 7271A—Rings, Sealing, Synthetic Rubber—Fuel and Low Temperature Resistant (60–70)

- AMS 7272—Rings, Sealing, Synthetic Rubber—Synthetic Lubricant Resistant (65–75)—Buna-N Type

- AMS 7275—Rings, Sealing, Synthetic Rubber—Synthetic Lubricant Resistant (65–85) Fluorocarbon Type

- AMS 7705—Magnetic Alloy—Nickel-Iron Alloy

- AMS 7720—Lead Alloy Castings—6.5Sb-0.5Sn

- AMS 7721—Lead Alloy Sheet and Extrusions—6.5Sb-0.5Sn

(The above, plus a new Index of all Aeronautical Material Specifications, may be obtained from SAE Headquarters for $6.15.)

New Members Qualified

These applicants qualified for admission to the Society between June 10, 1957 and July 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Henry William Higgins (A), Jacob Janzen (M).

Baltimore Section

John Richard Clark (M), Tibor F. Nagey (M).

British Columbia Section

Donald Arthur Anderson (M), Jack Ballard (A), John Kerr (A), Marvin Wilson (A).

Canadian Section

Frank C. Cullimore (M), James Gilbert Dow (M), C. H. Harvey (A), David Lloyd Jones (M), Von R. Kaufman (M), Thomas Melville Mayberry (A).

Central Illinois Section

Glenn A. Ball (A), Noble G. Barker (A), Glenn I. Branstad (J), Arthur L. Jameson (J), Gary H. Kling (J), Fred M. Szabados, Jr. (J), Donald F. Webster (J).

Chicago Section

Robert W. Brooks (A), David John Bundy (M), Jeanie S. Christie (M), Thomas E. Clague (A), Norman W. Felbinger (M), C. Don Hicks (A), Roger S. Hutton (M), Robert H. Klopp (M), Richard L. Nix (B), John Philpott (M), Earl Allen Wagner (M), Vernon C. Westberg (M), Ralph D. Wysong (M), Leonard D. Zemeck (J).

Cincinnati Section

William G. Cornell (M), Kurt P. Halbert (M), Karl W. Kalb (A).

Cleveland Section

Dean R. Christian (M), William F. Collier (A), Harry L. Dregalla (M), Frank H. Kramen (M), Charles O. Parratt (M), Miss Phyliss P. Whalen (A).

Colorado Group

William Gene Andrews (A), George Myron Jones (A).

Dayton Section

John B. Day, Jr. (J).

Detroit Section

Edmund T. Barbour (A), William James Bell (A), Frederick P. Bens (M), Charles August Bienenstein (M), Glen L. Bowen (M), Kenneth N. Donelson (J), Perry C. Dooley (J), Samuel A. Findley (M), Wilbur L. Frayer (J), Wesley S. Harjala (J), Roy C. Harrison (A), Paul W. Hehr (A), Neal Hepner (M), Paul F. Hood (M), Eugene H. Jary (M), Luther N. Kern (M), Robert E. Klare (M), George Peter Manasa (A), Leonard H. Mapes (A), Robert M. Mello (J), James L. Molnar (M), Robert D. Neuharth (J), Harland W. Oates (M), Gordon A. Peterson (A), Richard H. Pickering (J), Donald F. Rundle (M), Owen C. Russell (J), Jerold Walther Scheel (J), Mirza Jay Shustary (J), Alfred R. Smith (J), Ben J. Smith (M), Samuel J. Smoly (M), George Sobol (M), Ross E. Taylor (M), John J. Torsok (A), Kenneth Wayne Van Dyke (A), Harvey E. Wortz (M).

Hawaii Section

Stephen Richard Benchwick (A).

Indiana Section

Donald E. Chalfant (M), Robert J. Muehlausen (M), Glenn F. Whiteley (M), Dean L. Williams (A).

Kansas City Section

Willard C. Betteridge (A), Benjamin W. Bogdan (M), George F. Moore (M).

Metropolitan Section

Robert E. Barnum (M), Francis H. Eipper (A), Arch L. Herron (M), Rob-

Continued on page 140

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Mechanical and Electrical Engineers, with a personal interest in precision mechanisms, where a high degree of accuracy is required, and a pride in the precision of the product they help build, we offer truly challenging opportunities.

You will do development work and testing in one of the country's most versatile laboratories, working with the top men in the field and the finest test, research and development equipment. As a part of our Major, Permanent, Expansion Program, new plant facilities are being added in suburban Milwaukee.

AC provides financial assistance toward your Master's Degree. Graduate program also available evenings at Univ. Wisconsin, Milwaukee. GM's aggressive position in the field of manufacture and GM's policy of decentralization creates individual opportunity and recognition for each Engineer hired.

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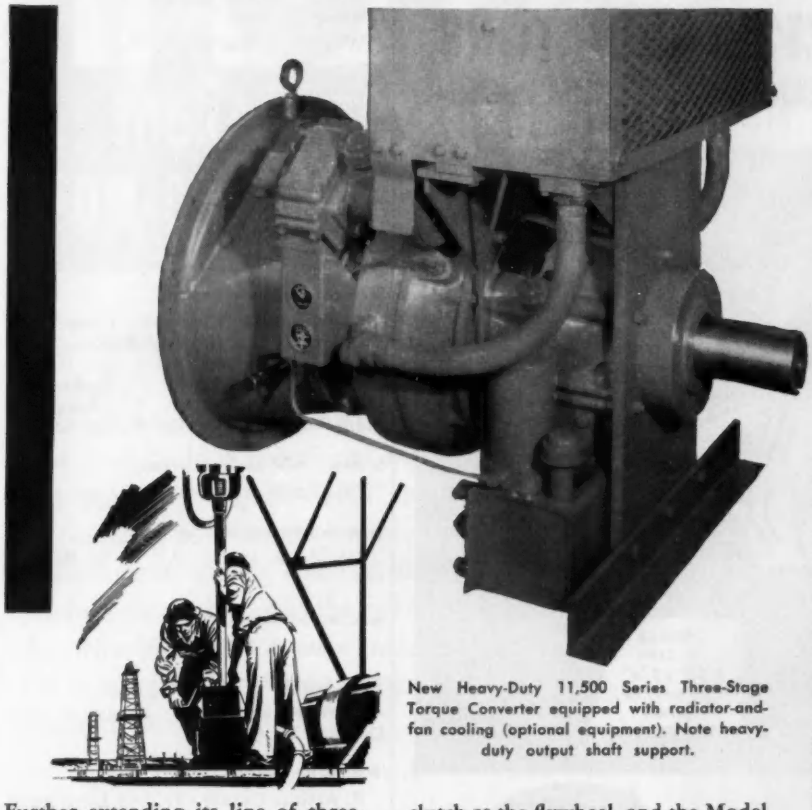
THE ELECTRONICS DIVISION

GENERAL MOTORS Corporation

FLINT 2, MICH. MILWAUKEE 2, WIS.

Twin Disc announces new Heavy-Duty 11,500 Series Torque Converter



New Heavy-Duty 11,500 Series Three-Stage Torque Converter equipped with radiator-and-fan cooling (optional equipment). Note heavy-duty output shaft support.

Further extending its line of three-stage torque converters, Twin Disc Clutch Company now offers industry an additional version of its popular 11,500 Series Three-Stage Torque Converters.

Designated the Heavy-Duty 11,500 Series (a Standard-Duty version will be continued), the new units have a maximum rating of 586 hp at 2200 rpm. Maximum input torque is 1400 pound-feet. Impellers are available for specific torque ratings of 340, 390, 450 and 540 pound-feet.

Current production units include the Model CF, which provides a clutch at the flywheel, and the Model F, which is connected to the flywheel with a driving ring.

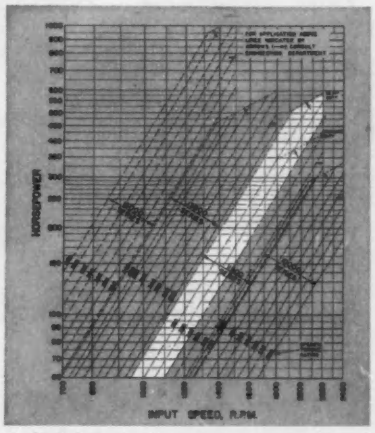
A Twin Disc C-3 Rear End, with the output shaft supported by two heavy-duty roller bearings, is available with either model, permitting maximum output sidepull.

The complete line of Twin Disc Three-Stage Torque Converters includes five distinct sizes; the 10,000 Series, Standard-Duty 11,500 Series, Heavy-Duty 11,500 Series, 13,800 Series and the 16,000 Series. The line offers 33 specific torque ratings and input and output arrangements to meet virtually every industrial requirement from 60 to 1000 hp and from 700 to 2400 rpm.

These three-stage torque converters have long proved themselves on such applications as crawler tractors, drilling rigs, shovels, yarders, locomotives and many, many others. They offer such advantages as multiplying engine input torque (up to 6:1) exactly as required by load . . . cushioning out destructive shocks and vibrations . . . minimizing maintenance and downtime . . . and *producing more work on a hp-cost basis.*

Twin Disc, the only manufacturer producing both three-stage and single-stage designs, offers single-stage torque converters for engines producing 30 to 212 hp. Besides this, Twin Disc makes available a complete line of fluid couplings, to 850 hp, and friction clutches, to 1050 hp.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois . . . with parts and service facilities throughout most of the world.



Unshaded area in above curves compares hp and rpm characteristics of the Heavy-Duty 11,500 Series Torque Converter with other Twin Disc Three-Stage Torque Converters.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

New Members Qualified

Continued

ert A. Keyes (M), Richard R. Staebler (M).

Mid-Michigan Section

Alexander Bleshenski (A), Dennis E. Condon (J), Hubert L. Curtis (M), Thomas E. Darnton (M), William Stuart Hayes (J), Donald C. Ruschman (M).

Milwaukee Section

Nicholas Peter Arvon (M), Bruce Deyo (J), J. F. Gettrust (A), Clemens A. Johnson (J), Clarence R. Martin (M), Louis C. Mente (M), Harry E. Wolcott (M).

Mohawk-Hudson Section

Angelo Di Sorbo (A), Robert Don (M).

Northern California Section

Richard C. Bouma (J), Eugene C. Jacobson (A), C. C. Mugford (M), Robert E. Nicholson (A), Robert Lee Woolf (A).

Northwest Section

John J. Shorkey (M).

Oregon Section

Donald Elbert Aldrich (A).

Philadelphia Section

Robert Bruce Koch (M), George B. Myrtetus (J).

Pittsburgh Section

William A. Farmer (M).

St. Louis Section

George R. Buchanan (M), Fred Kramer, Jr. (J), Walter C. May (J), Clarence F. Westfall (M).

San Diego Section

Donald M. McGrath (M), Ronald George Stantone (M), Noah F. Wessinger, Jr. (J).

Southern California Section

Charles E. Barnes (M), Edward M. Brodersen (M), Harrold Rickey Cochran (M), Jose de Kastro (J), Robert J. Gottlieb (A), Jack F. Harrington (M), Francis C. Morris (M), Joseph A. Palm (A), John Taylor Wilson (J).

Southern New England Section

Charles G. Graef (M).

Spokane-Intermountain Section

Donald E. Bruce (A), O. R. Parrish (A).

Syracuse Section

Preston S. Billings (A).

Texas Section

J. W. Ferris, Jr. (A), George S. McDonald, Jr. (J).

Washington Section

S. Arthur Casale (J), 2nd Lt. Donald M. Lenef (J).

Western Michigan Section

Royce G. Engel, Jr. (M).

Williamsport Group

Earl Louis Wilkinson (M).

Outside Section Territory

Bruce B. Burket (M), Edward Drott, Jr. (M), Melvin E. Long (J), J. W. Looney (A), George E. McDonald (M), Lt. Col. John P. Stapp (M).

Foreign

Ernesto E. Blanco (A), Cuba; Dino Dini (M), Italy; James Raeburn Milne (M), Saudi Arabia; Auguste Francois Moiroux (M), France; Theodor Ries (M), Belgium; Hans Weber (M), Switzerland.

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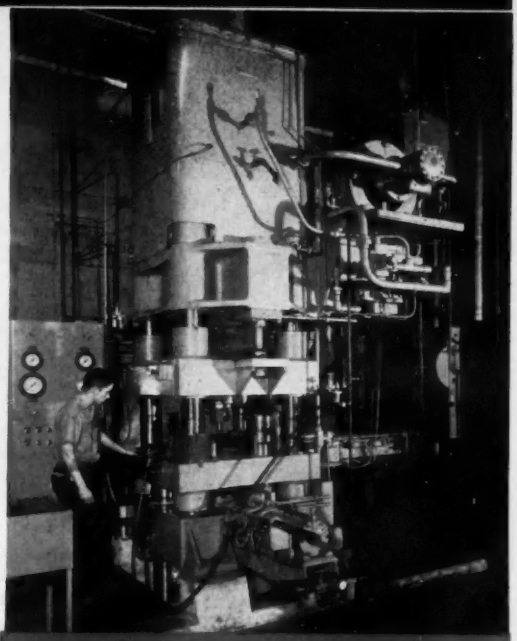

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Applications Received

The applications for membership received between June 10, 1957 and July 10, 1957 are listed below.

Atlanta Section

William E. Perdue, Jr.

Baltimore Section

John Thomas Ramsden.

British Columbia Section

Gwynn Jenkins.

Buffalo Section

Lewis L. Dollinger, Jr., John W. Godfrey, Gene Grammatico, Alfred J. Taylor, Paul F. Wilber.

Canadian Section

Hector M. Lazzarotto, Augustine A. P. McGowan, Ian H. Mitchell, James Alfred Montgomery, Charles A. Speers, William Frank Wakeling.

Central Illinois Section

Lloyd K. Heinold, Kenneth R. Moline, Harold C. Stone.

Chicago Section

Delmar Clyde Hepker, M. E. Samuelson, James W. Scott.

Cincinnati Section

Robert L. Hardin, Jr.

Cleveland Section

Charles A. Hall, Robert C. Holmgren, Charles W. Nehr.

Dayton Section

Larry D. Creeger, Kermit D. Kuhl, William G. McLaughlin, Walter E. Moore, John Arthur Moran, Harry A. Nelson, Arland W. Rike.

Detroit Section

Charles Robert Aumann, Edward G. Benya, John F. Boyle, Ernest G. Davis, Robert F. Falberg, Frank G. Falvey, Donald W. Hamilton, Mohamad Mounir Kamal, Robert E. Kay, J. W. Knoblock, Frank S. Kuharich, Richard W. Malcolmson, Wesley A. Maze, Dale A. Palmer, Robert Pearce Skye, Raymond Violante, Malcolm Edward White, Robert Lee Wolfe.

Indiana Section

James Philip Carpenter, Eugene Charles Suding.

Kansas City Section

Harlan C. Ganung, Richard Lea Humphrey, Elmer E. Litton, Wilfred Regenbogen.

Metropolitan Section

Jonathan E. Boretz, Dallas W. Breeden, Joseph H. Chislow, Richard L. Demmerle, A. Norton Drake, Frank M. Emmans, Eugene J. Faust, Robert M. Flanagan, Webber H. Glidden, Dudley T. Himoff, J. Gordon Hoffman, Karl H. Neulinger, Henry J. Ogorzaly, Frank P. Reggio, Henry Rottersman, Harvey Murray Scherr, Ernest Albert Samuelsen, William Spontak, Edward Szczech, James B. Treacy.

Mid-Michigan Section

Joseph N. Goulish, Bill A. Stout.

Milwaukee Section

Walter Clarke Anold, E. J. Biever, Rex L. Curry, Robert L. Greivell, Harold J. Lonn.

Mohawk-Hudson Section

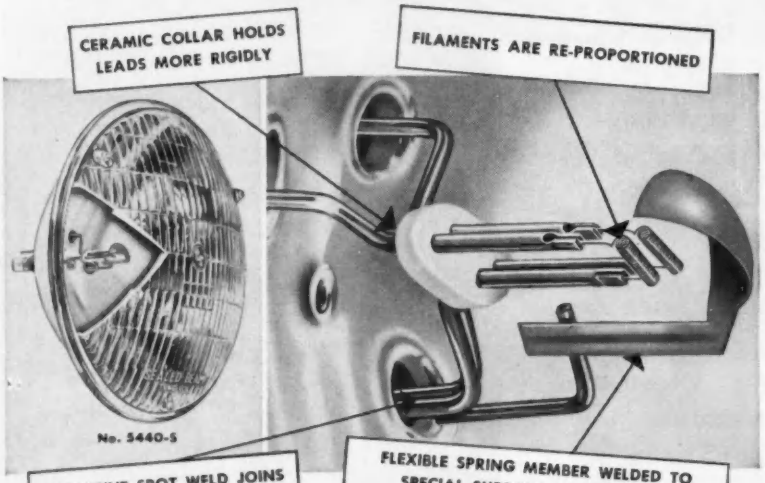
James W. Cummings.

Montreal Section

George H. Schilling, Lawrence Kenneth Steels.

Continued on page 144

THE MOST RUGGED TRUCK AND BUS HEADLAMP EVER BUILT!


CERAMIC COLLAR HOLDS LEADS MORE RIGIDLY
FILAMENTS ARE RE-PROPORTIONED
No. 5440-S
EXCLUSIVE SPOT WELD JOINS TWO LEAD WIRES TOGETHER
FLEXIBLE SPRING MEMBER WELDED TO SPECIAL SUPPORT, SHOCK-MOUNTS FOG CAP TO LESSEN FILAMENT VIBRATION

The Tung-Sol Vision-Aid Truck Headlamp, long recognized for meeting the toughest service conditions, is now more durable than ever before. This new ruggedness is produced by spot welding two of the lead wires together (an exclusive Tung-Sol feature) and by use of a ceramic collar which stiffens the entire filament structure. Also, the filaments themselves have been re-proportioned—thus making the filaments less receptive to vibration and shock. Flexible anti-shock spring member welded to special support isolates fog cap from filament structure.

Exhaustive laboratory impact tests clearly reveal that this new lamp will stand more abuse than any previous headlamp.

In addition to durability, improved vision in bad weather is provided by the fog cap, and quick day or night aiming is made possible by the E-Z Aim Platforms. Drivers, equipment and cargoes are safer at night behind Tung-Sol Vision-Aid Headlamps, and they cut lamp replacement costs in the bargain.

TUNG-SOL ELECTRIC INC.
Newark 4, N. J.

Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Montreal, P. Q.

TUNG-SOL®
No. 5440-S RUGGEDIZED
VISION-AID HEADLAMPS
WITH E-Z AIM PLATFORMS

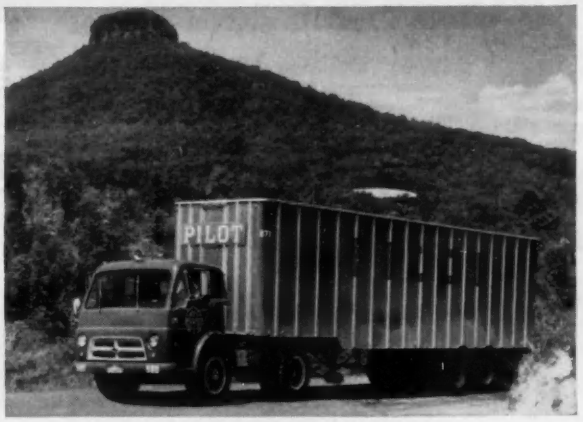
BENDIX-WESTINGHOUSE AIR BRAKES
Best buy for your trucks because they're preferred by America's leading fleet operators!

"DURING OUR 30 YEARS IN BUSINESS

We've bought 1500 trucks—and when it comes to Air Brakes, we prefer BENDIX-WESTINGHOUSE!"

MR. HERBERT S. McCARTHY,
Vice-President and General Manager
California Motor Express, Ltd.

From general headquarters in San Francisco, Mr. McCarthy directs the activities of one of California's leading trucking firms. Operating from Sacramento in the north to San Diego in the south, California Motor Express, Ltd., pioneered "overnight" service between the San Francisco Bay area and greater Los Angeles. The company rolled up some 8,000,000 miles in 1956 while operating on routes totaling 1,500 miles. California Motor Express, Ltd., maintains thirteen terminals and employs 850 people.



"DURING OUR 16 YEARS IN BUSINESS

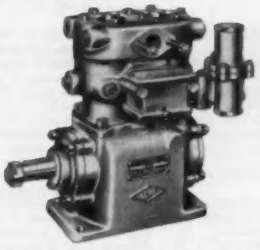
We've bought 769 trucks—and when it comes to Air Brakes, we prefer BENDIX-WESTINGHOUSE!"

MR. E. Y. SHARPE, *President*
Pilot Freight Carriers, Inc.

For sixteen years Pilot Freight Carriers, Inc., has provided fast, efficient motor freight service along the eastern seaboard. With headquarters in Winston-Salem, N. C., this progressive firm last year rolled up a total of over 19 million miles while operating on all principal highways within a twelve state area. Pilot Freight Carriers, Inc., a highly safety-conscious organization, has developed two national champion and five state champion drivers. The company maintains 26 strategically located terminals and agencies and employs nearly 1,000 people.

For twenty-seven years Bendix-Westinghouse Air Brakes have been the first choice of truck manufacturers and truck operators everywhere, consistently outselling all other makes of air brakes combined. In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on an ever-increasing number of truck models of all sizes.

Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest that you take advantage of the proven preference and superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales-appeal to your vehicles!

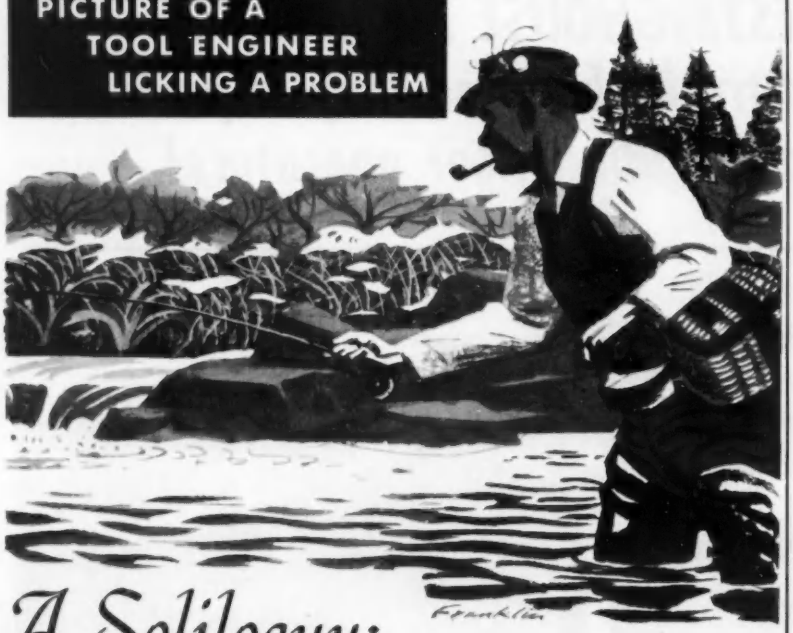


Over 2,000,000 compressors, produced over a twenty-seven-year span, stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General offices and factory—Elyria, Ohio. • Branches—Berkeley, Calif., and Oklahoma City, Okla.

PICTURE OF A
TOOL ENGINEER
LICKING A PROBLEM



A Soliloquy:

"Lucky I switched to 921-T on that Friday project, or I wouldn't be out here whipping this stream today. Funny, how that one material met all the problems; maximum stability, easy machinability, light weight — everything the old man wanted, and at less cost.

"I can see where 921-T could be used on every job on the board, and maybe a few that haven't been dreamed up yet. Come Monday, I'll recommend to Purchasing that we put in a stock of Pioneer 921-T and standardize on it for everything. It saws, taps, mills and welds so easily, a lot of material waste could be avoided. Boy . . . that's one for the suggestion box."

Pioneer 921-T cast aluminum tooling plate is a worry antidote for tool engineers. To get the complete story of its universal adaptability to form blocks, stretch form dies and jig components of all kinds, call your nearest Pioneer distributor for a copy of the new 921-T brochure.

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Richard G. Evans, Mgr.
23439 Michigan Ave., Dearborn, Mich.

SOUTHWEST REGIONAL SALES MANAGER:
Howard L. Hutchinson, P.O. Box 702, Dallas, Tex.

PIONEER ALUMINUM INC.
Subsidiary of MORRIS P. KIRK & SON, INC.
PACIFIC COAST UNIT OF NATIONAL LEAD COMPANY
5251 West Imperial Highway • ORegon 8-7621 • Los Angeles 45, California.

TOOLING PLATE
HEATING
PLATENS
VACUUM CHUCKS
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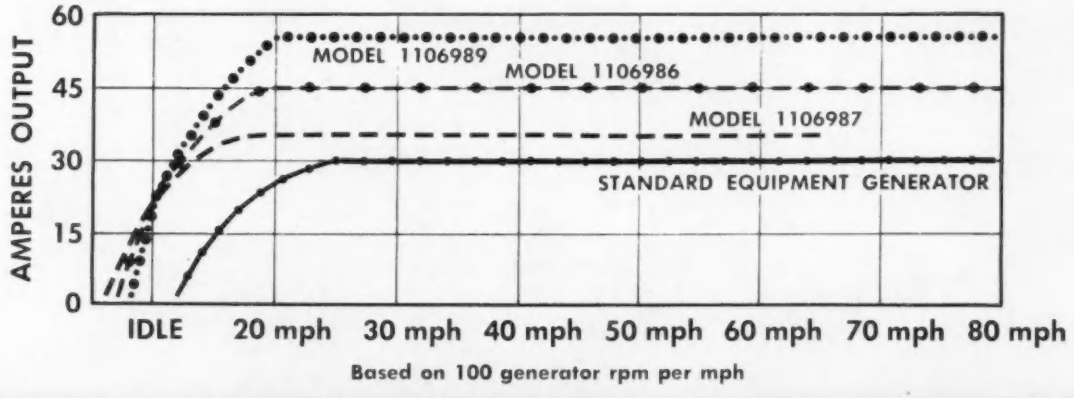
DELCO-REMY ANNOUNCES NEW LINE OF EXTRA-OUTPUT GENERATORS AND REGULATORS FOR—

- *Substantial charge at engine idle*
- *Full output at low driving speeds*
- *Electrical and mechanical stability at high driving speeds*

Now for the first time, a Delco-Remy extra-output d.c. generator, with matching *double contact* regulator, can offer all these outstanding performance characteristics in a single unit. The new line is designed for vehicles requiring high output at low speeds combined with rugged dependability at high speeds.

HERE IS A TYPICAL CHOICE OF UNITS TO SUIT YOUR NEEDS:

Model (12V)	Current Rating	Max. Recommended RPM
1106986	45 amp.	8,000
1106986	50	6,500
1106987	35	6,500
1106989	55	8,000



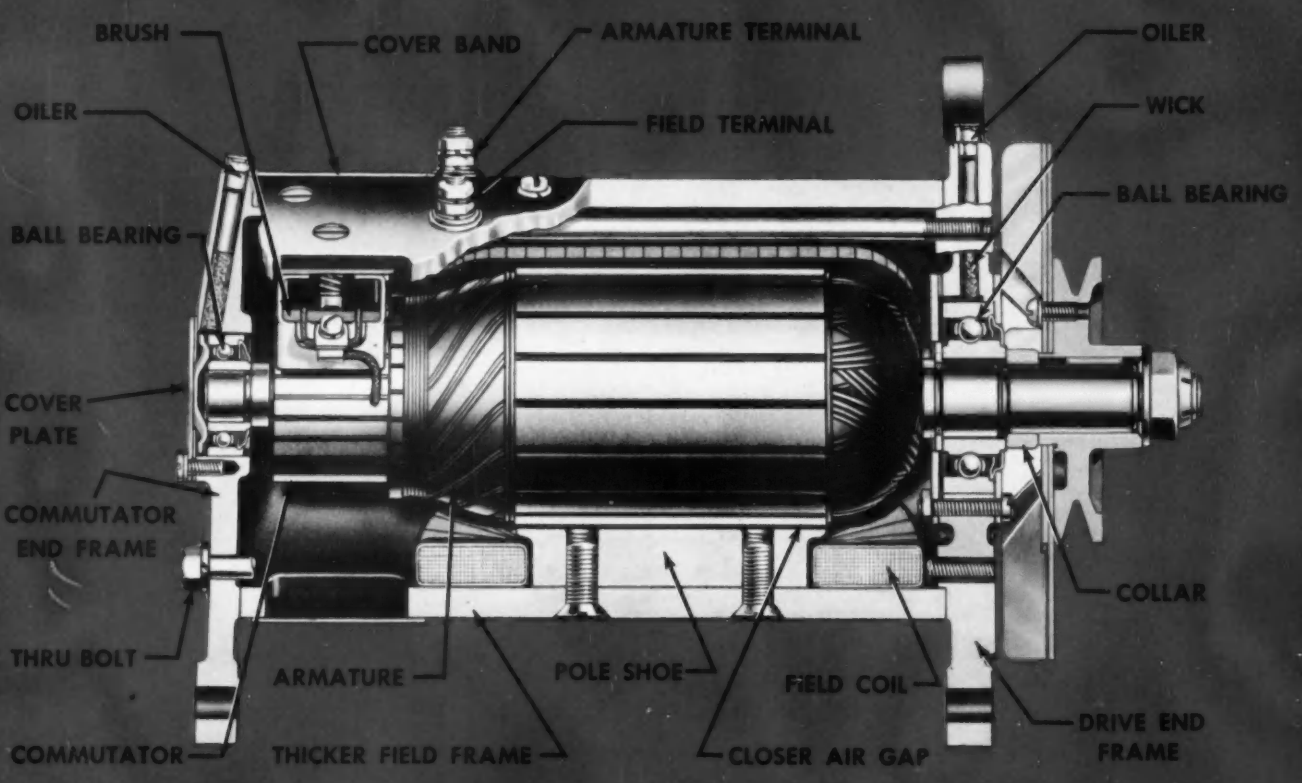
Based on 100 generator rpm per mph

Here is the inside story of the new Delco-Remy power team →

NOW—AN OUTSTANDING NEW DELCO-HIGH OUTPUT AT LOW SPEED

Electrical and mechanical features of these new generators which make possible the improved performance over regular extra-duty models include:

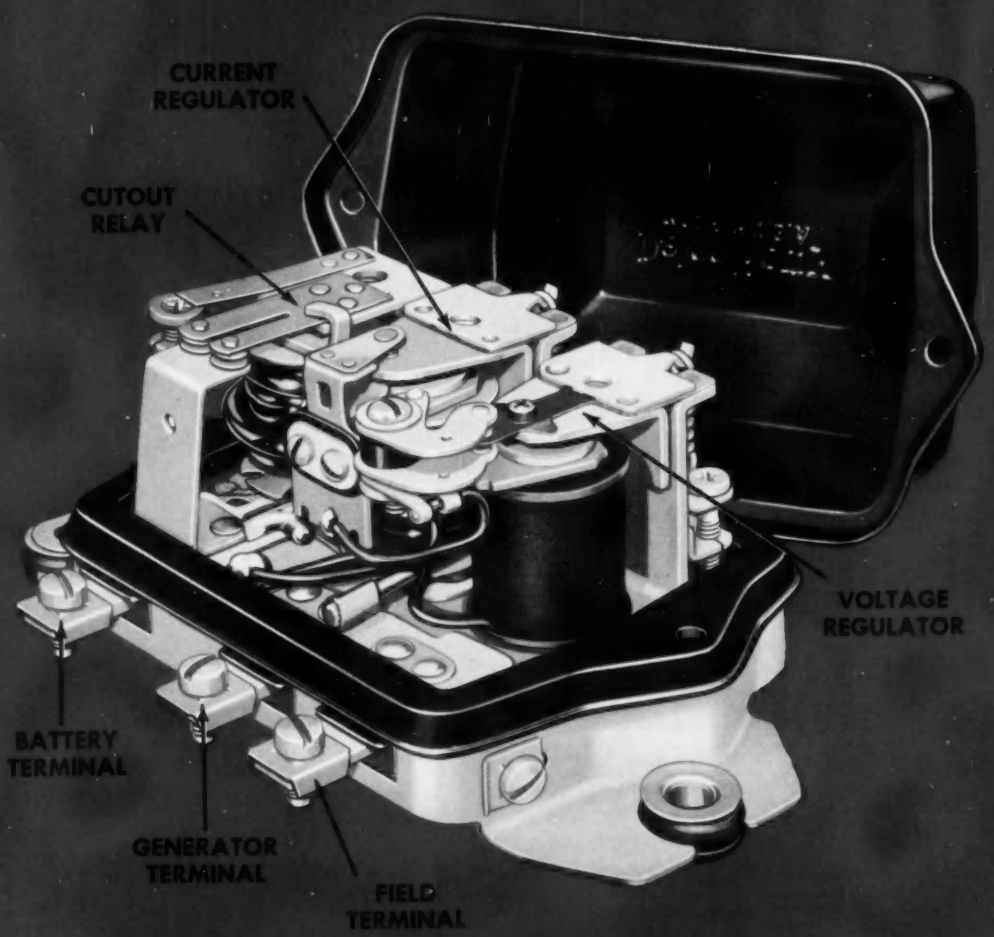
• Closer air gap held to exact tolerances • Longer, thicker frame for increased magnetic flux (Frame dimensions: 5¾″ x 9½″) • Longer commutator and larger brushes • Ball bearings at both drive and commutator ends • Wick oiler lubrication • Higher field currents made possible by a new double contact regulator



DELCO-REMY EXTRA-OUTPUT D.C. GENERATOR

REMY POWER TEAM TO GIVE YOU — RUGGED DEPENDABILITY AT HIGH SPEED

Developed as a part of the revolutionary power team, Delco-Remy's new double contact voltage regulator makes possible the new special series of high performance extra-output d.c. generators. Because of its double contact design, the new regulator offers precise two-stage control of generator field current at low and high generator speeds. This permits the use of high generator field currents necessary for a substantial charge at engine idle without excessive contact point deterioration or loss of voltage control at high speeds. What's more, the new regulator is waterproof and has all the latest mechanical features.



DELCO-REMY DOUBLE-CONTACT REGULATOR

FOR DEPENDABLE, ECONOMICAL ELECTRIC POWER FOR COMMERCIAL VEHICLES REQUIRING—

1. Substantial charge at engine idle
2. Full output at low driving speeds
3. Extra high capacity
4. Fully controlled output at high speeds

Some typical applications

School buses
Police cars
Highway wreckers
Suburban fire equipment
Taxicabs
Ambulances
Transit mix trucks
Lift trucks
Sanitation trucks

get the new Delco-Remy electrical power team:

- Delco-Remy *extra-output* d.c. generator
- Delco-Remy *double contact* regulator

This revolutionary new line of high performance generators and regulators designed for dependable service under a wide range of operating conditions is another example of Delco-Remy leadership "Wherever Wheels Turn or Propellers Spin."

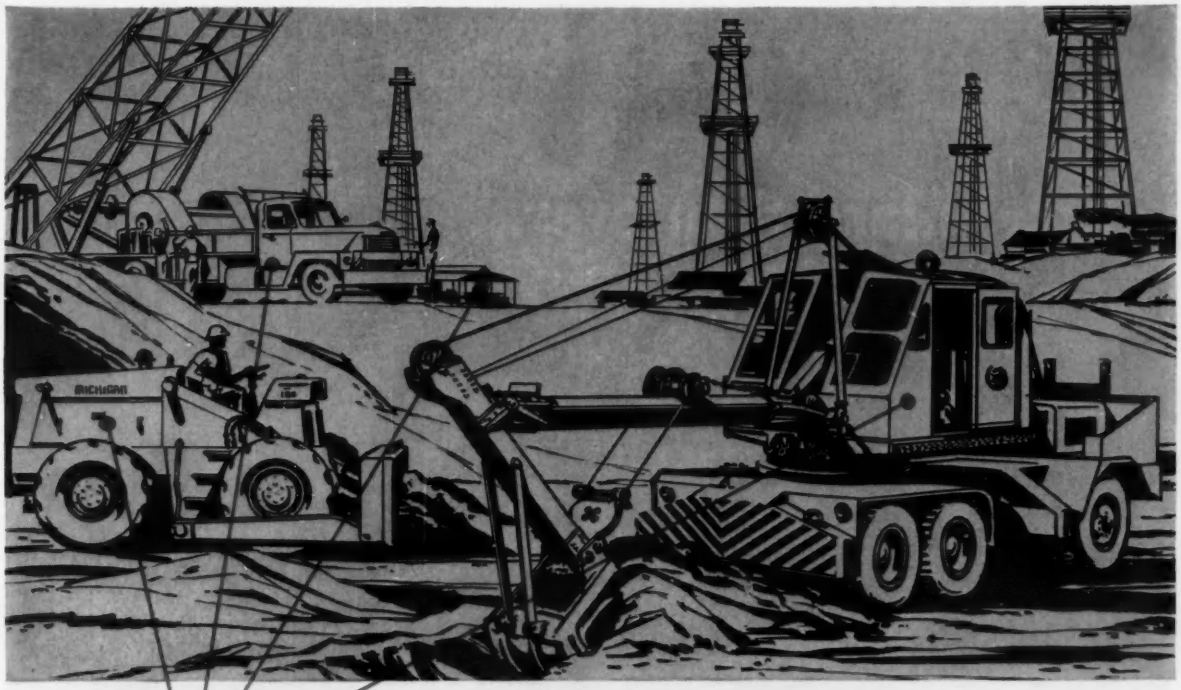
DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

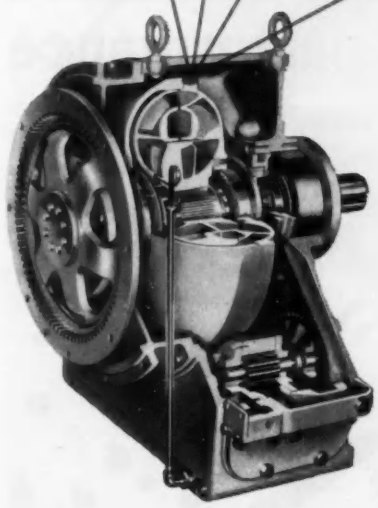
GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY—STARTING WITH

Delco-Remy

ELECTRICAL SYSTEMS





It can be done! – –

That engine will DO MORE, LAST LONGER with a CLARK Torque Converter

You are sure of top engine performance and minimum wear when you use a Clark Torque Converter. Your engine may be operated all the time at its most efficient speed, with power output adjusted to the job's torque demand. And the smooth, steady flow of shockless power eliminates shock loads—reduces strain and wear on all working parts, in engine *and* power train.

These features are dependable working proof of Clark excellence:

- **True Hydra-Foil Blade**—an exclusive design of blade contour, maximum efficiency in torque build-up
- **No Cavitation**—proper oil flow prevents turbulence and air pockets to cause efficiency losses and wear
- **Ideal Accessibility**—easiest possible inspection and maintenance. No special tools required
- **Self-Contained Oil Circuit**—oil sump and passages cast in housing. No unnecessary fittings, no leakage
- **Complete Line**—horsepower 15 to 600; diameters 11" to 26"

Helpful literature sent promptly—use the coupon.

CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY, Falahee Road, Jackson 5, Mich.: Please send the CLARK Torque Converter Bulletin

Name_____ Position_____

Firm_____ Address_____

City_____ Zone_____ State_____

Enjay Butyl adds to new car performance

Here are 104 of the Enjay Butyl rubber parts contributing to the outstanding performance of the 1957 Pontiac cars.

Enjay Butyl, the super-durable, all-weather rubber, has been Pontiac's choice for important rubber parts for the past eleven years. This year, in more parts than ever before, Enjay Butyl rubber is adding strength, durability, and beauty for safer, more luxurious driving.

Readily available in non-staining grades, Enjay Butyl rubber can be compounded into white and light-colored parts that combine beauty with top-notch performance. Low in cost, it out-performs and out-lasts all other rubbers formerly used, and may well be able to *cut costs* and *improve performance* in *your* product. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world... the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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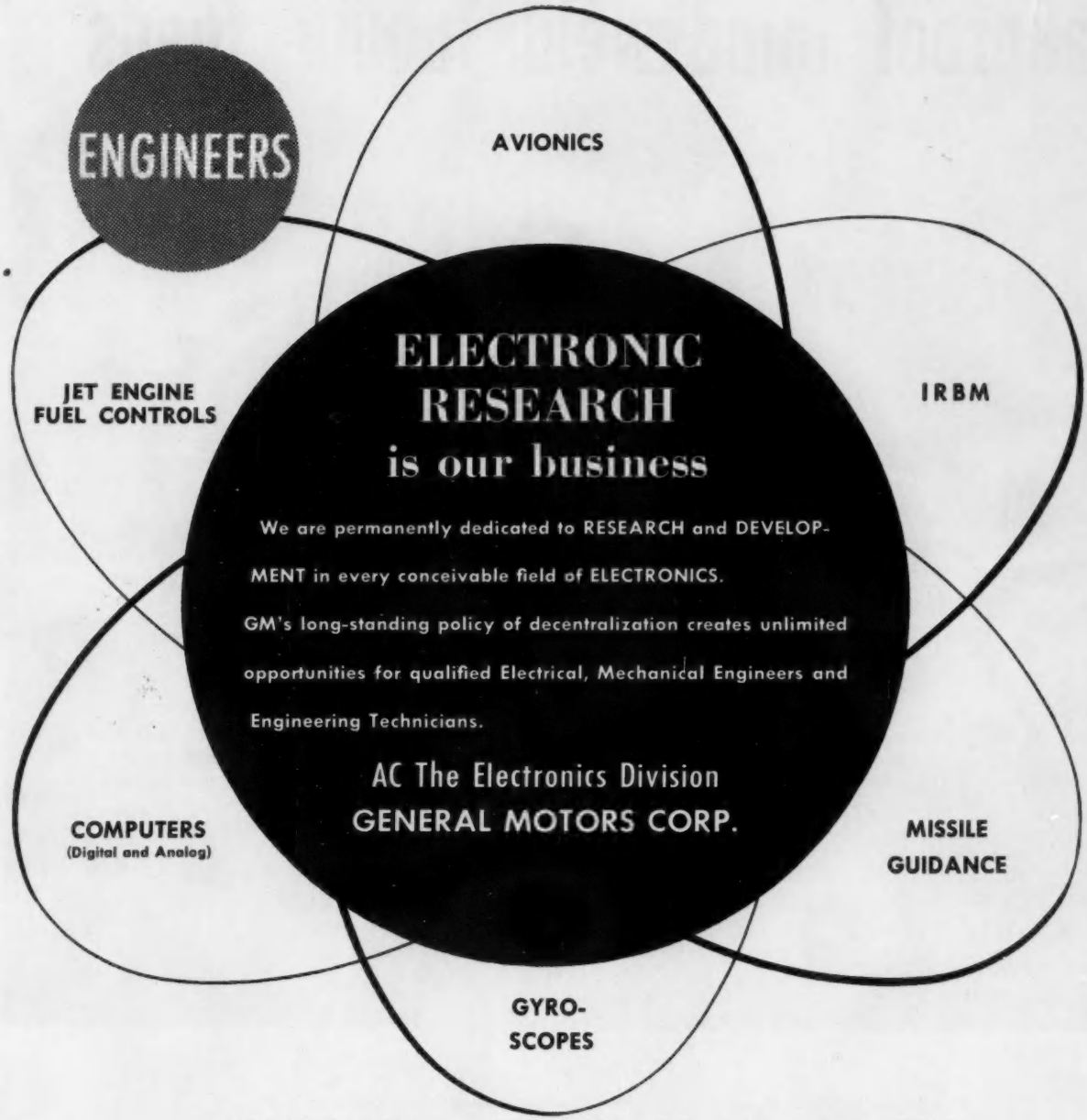
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ELECTRONIC RESEARCH is our business
We are permanently dedicated to RESEARCH and DEVELOPMENT in every conceivable field of ELECTRONICS.
GM's long-standing policy of decentralization creates unlimited opportunities for qualified Electrical, Mechanical Engineers and Engineering Technicians.
AC The Electronics Division
GENERAL MOTORS CORP.
COMPUTERS (Digital and Analog)
MISSILE GUIDANCE
GYRO-SCOPES

New plant (225,000 square feet) now being built in a Milwaukee suburb. This and our present plant will house the ELECTRONICS DIVISION—Milwaukee of the General Motors Corporation.

Your future is assured (if you can qualify) in this lovely cool, southern Wisconsin city where every conceivable living and cultural advantage, plus small town hospitality is yours for the asking. Send full facts today about your education, work background, etc. Every inquiry treated in strict confidence—and you will hear from us by return mail.

For Employment Application — Mr. Cecil E. Sundeen, Supervisor of Technical Employment

AC THE ELECTRONICS DIVISION
GENERAL MOTORS CORPORATION
Milwaukee 2, Wisconsin Flint 2, Michigan

Leakproof Bundyweld Tubing feeds

This double exposure shows how a driver can raise or lower the Citroën body at will, when traveling rutted roads or when changing tires. In normal operation, height-corrector valves automatically maintain proper road clearance, regardless of load. The system provides independent suspension for each wheel; depends on leakproof Bundyweld Tubing to carry its hydraulic fluid without failure.

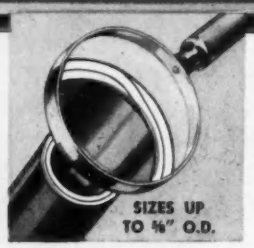
BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.



←

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

Citroën's hydro-pneumatic suspension*

Transmission, clutch, brakes, and steering also served by centralized hydraulic system through reliable Bundyweld

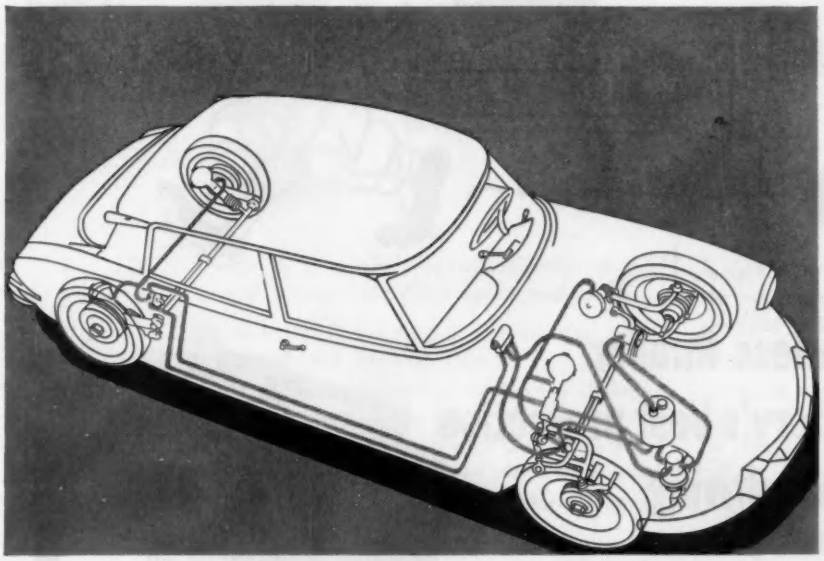
Fabulous is the word for Citroën's unique hydro-pneumatic suspension. It utilizes a combination of oil and inert gas under pressure to soak up every last jolt and jar for a cloud-soft ride. But Citroën's suspension and other power-assisted components need an unending supply of hydraulic fluid. And this is delivered unfailingly through Bundyweld Tubing®.

Ultrareliable is the word for Bundyweld Tubing. Because it is the only tubing double-walled from a single steel strip, then metallurgically bonded through 360° of wall contact, Bundyweld is amazingly strong and resistant to vibration fatigue . . . *leakproof by test.*

This same exclusive process gives Bundyweld high bursting strength and tensile strength . . . makes it smooth, ductile and easy to fabricate, even in the most complex shapes. These properties are the reasons *Bundyweld is used on 95% of today's cars, in an average of 20 applications each!*

Whether you want tubing straight, coiled, or fabricated precisely to specification, Bundy® will handle the job. Your tubing will be packaged carefully, delivered right on schedule — clean, bright and ready to use. And Bundy offers free, expert engineering service as well. Need tubing for mechanical or fluid transmission applications on cars, trucks, or farm equipment? Chances are you'll save time and money by checking first with Bundy. Call, write, or wire us today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN



Heart of Citroën's centralized hydraulic system is a high-pressure, 7-piston pump which drives hydraulic fluid into a constant-pressure accumulator. From there, it feeds through dependable Bundyweld Tubing to the suspension, shown in schematic diagram at left. Other power-assisted components: *Clutch* — standard-type automatically disengages when gearshift is moved, or engine rpm's fall to idling. *Transmission* — manual shift actuates hydraulic-assisted selector forks. *Brakes* — two separate Bundyweld lines supply front disc brakes and rear drum brakes. *Steering* — hydraulic cylinder moves standard rack and pinion either way on demand.

**Citromatic®*

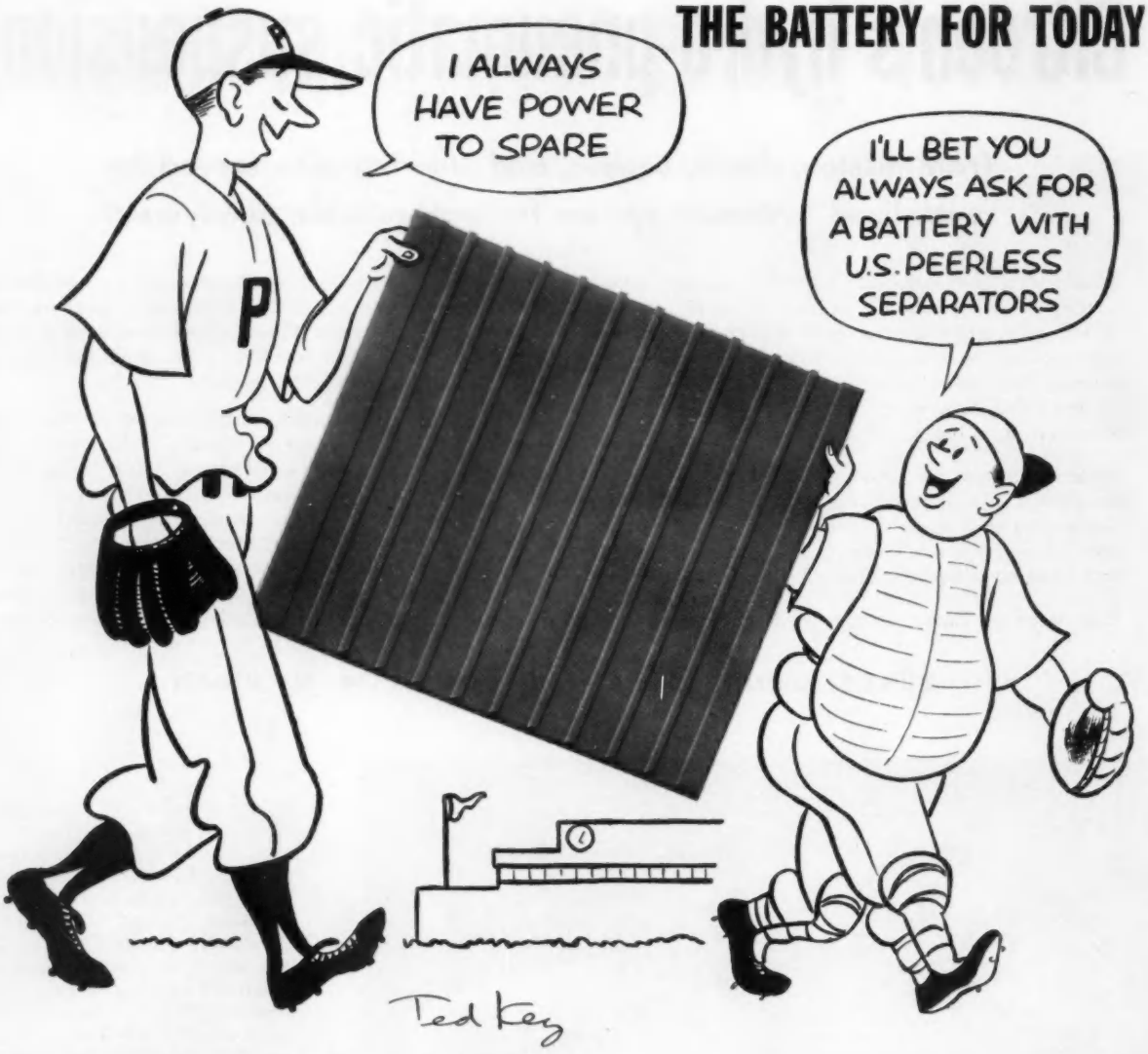
BUNDYWELD® TUBING

Bundy Tubing Distributors and Representatives: ***Massachusetts:*** Austin-Hastings Co., Inc., 226 Binney Street, Cambridge 42 • ***Pennsylvania:*** Rutan & Co., 1 Bala Ave., Bala-Cynwyd • ***Midwest:*** Lapham-Hickey Steel Corp., 3333 W. 47th Place, Chicago 32, Ill. • ***South:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg., Chattanooga 2, Tenn. • ***Southwest:*** Vinson Steel & Aluminum Co., 4606 Singleton Blvd., Dallas, Texas • ***Northwest:*** Eagle Metals Co., 4755 First Avenue, South, Seattle 4, Wash. • ***Far West:*** Pacific Metals Co., Ltd., 2187 S. Garfield, Los Angeles 22, Calif. • Pacific Metals Co., Ltd., 1900 Third Street, San Francisco 7, Calif.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

THE BATTERY FOR TODAY



Here's why U. S. Peerless Rubber Separators are a battery's best protection in the heat of summer driving

It's in the heat of summer that the ordinary battery gets damaged, and therefore cannot deliver full power in cold weather. But a battery equipped with Peerless® Separators is protected against damage by heat ... and therefore delivers more power and more cranking speed in cold weather. Because of lower electrical resistance than that of ordinary separators, U. S. Peerless provides higher voltages and higher rates of current. They are not damaged by overcharging, battery acid or plate pressures. Make sure the batteries you order are protected by U. S. Peerless Separators. United States Rubber, Rockefeller Center, New York 20, N. Y.

ASK FOR A SUPPLY OF THIS TAG

US RUBBER

Mechanical Goods Division

United States Rubber

There is NO SUBSTITUTE for a forging: NO SUBSTITUTE for Wyman-Gordon Experience

There is more to the superiority of the forged crankshaft than just strength.

No other method of fabrication can compare with the forging process for dependability. The uniformity and predictability of physical properties with minimum variance from piece to piece or from one location to another in the same piece is assured to the greatest degree by modern forging practice.

Top automotive engineers agree that the use of a forged crankshaft permits the design of a more compact engine which is a decided advantage when thinking in terms of limited space available and overall engine weight reduction.

As compression ratios increase and engine outputs go up the risk factor must be reduced. Again, the uniformity of quality in the backbone of the engine, the crankshaft, is most essential and made possible only by a forging.

There is NO SUBSTITUTE for a forging and in a forging there is NO SUBSTITUTE for WYMAN-GORDON quality and experience.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS • DETROIT, MICHIGAN

XXII

This is the twenty-second of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Normalizing Alloy Steels

There are several forms of heat-treatment commonly employed in the processing of alloy steels. Each in its own way modifies the mechanical properties and structures of steel, and each is chosen with a definite objective in mind. The five usual forms of treatment are normalizing, annealing, spheroidize-annealing, quenching and tempering, and stress-relieving.

In this particular discussion, let us consider briefly the purposes and effects of normalizing.

Normalizing is an operation in which the steel is heated to approximately 100 deg F above the upper transformation range, then cooled in still or agitated air. The basic purpose is to refine the prior structure produced by variations in finishing temperatures encountered in rolling or forging. The structure resulting from normalizing, being more uniform, will help create improved mechanical properties when the steel is subsequently reheated, liquid-quenched, and tempered.

There are times when large steel parts (heavy forgings, for example) cannot be liquid-quenched because of their size. In cases of this nature, the heat-treatment must consist of single or multiple normalizing followed by tempering.

High-temperature normalizing is sometimes used for grain-coarsening low-carbon alloy steels to promote machinability. (In high-temperature normalizing, steel is heated to more than 100 deg F above the upper transformation range.) At times it is possible to machine a steel in the air-cooled condition, the governing factor being the alloy content. However, the highly alloyed analyses may require annealing or tempering after normalizing, to decrease the hardness.

It is essential, when normalizing is employed, that free circulation of still or agitated air be provided. When air-cooling of individual bars or forgings is not practicable, the furnace charge should provide for some means of separation, such as racks or spacers.

If you would care to know more about normalizing, or any other phase of heat-treating, you are invited to consult with Bethlehem metallurgists. They have had long experience in such matters, and they know how each treating method affects the various alloy steels. They are always glad to give you any help you need.

And when next in the market, please remember that Bethlehem makes the full range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades. We can furnish what you need.

If you would like reprints of this series of advertisements from No. I through No. XX, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 20 subjects in the series are now available in a handy 36-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

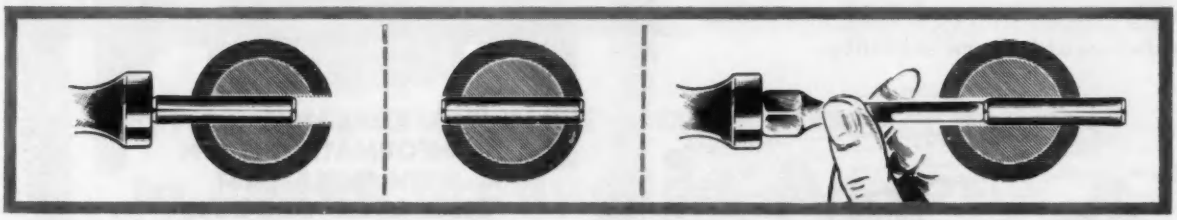
BETHLEHEM STEEL

what makes this fastener DIFFERENT?

Several things. Rollpin® is a slotted, chamfered, cylindrical spring pin which drives easily into a hole drilled to normal production standards. It locks securely in place, yet can be drifted out and reused whenever necessary. This eliminates special machining, tapping, and the need for hole reaming or precision tolerances. Rollpin replaces taper pins, straight pins and set screws; for many applications it will serve as a rivet, dowel, hinge pin, cotter pin or stop pin.

And here's another difference that makes Rollpin the quality fastener in the field: ESNA's quality control builds consistent strength and performance into every Rollpin. Rollpin is uniform as to shear strength, dimensions, hardness, and insertion and removal forces.

HOW YOU INSERT IT



Drives easily by hammer, arbor press, or air cylinder and can be readily adapted to an automatic hopper feed. Requires only a standard hole, drilled to normal production-line tolerances.

Locks securely in place without using a secondary locking device; won't loosen despite impact loading, stress reversals, or severe vibration.

Removes readily with a drift pin without damage to pin or hole, can be used again and again in original hole.

HOW YOU SAVE

You pay less for Rollpins than for most tapered, notched, grooved or dowel pins. Installation costs are substantially less than for any fastener requiring a precision fit or secondary locking operations.

Because of their tubular shape, Rollpins are lighter than solid pins. Production maintenance is reduced with Rollpins: they do not loosen and because of their spring action they tend to conform to the drilled hole in which they're inserted, without material hole wear, eliminating the necessity of re-drilling or using oversize pins.

MATERIALS AND SIZES

Standard Rollpins are made from carbon steel and Type 420 corrosion resistant steel. They're also available in beryllium copper for applications requiring exceptional resistance to corrosive attack, good electrical, anti-magnetic, and non-sparking properties. Stock sizes range from .062" to .500" in carbon and stainless steels.

ROLLPIN®

ELASTIC STOP NUT CORPORATION OF AMERICA

R40-875 **2330 Vauxhall Road, Union, New Jersey**

Please send me the following free fastening information:

- ☐ Rollpin Bulletin
- ☐ Elastic Stop nut Bulletin
- ☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

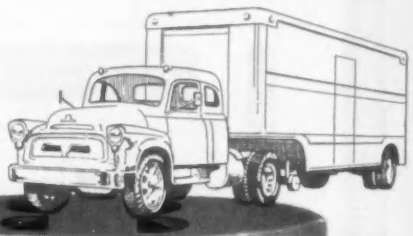
Firm_____

Street_____

City_____ Zone____ State_____

Rapidly becoming the

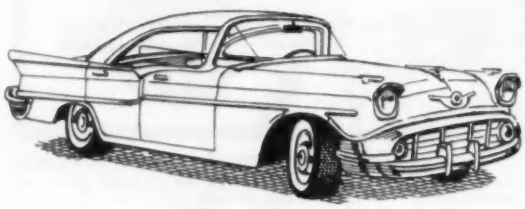
Standard of the Automotive Industry



INCREASES ENGINE LIFE UP TO 400%

STERLING'S great "Conformatic" piston with "Intra-Cast" steel ring groove liners give sensationally longer life to rings and grooves—

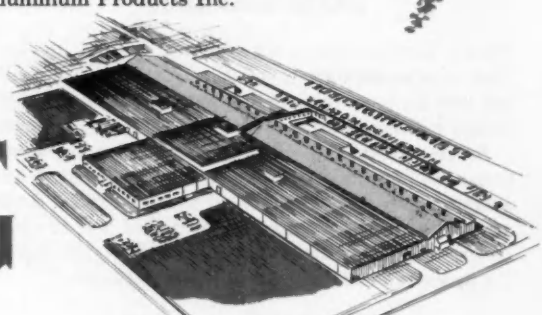
Recommended clearances for "Conformatic" pistons are from 0 to ½ thousandth inch. This clearance is maintained hot and cold providing unbelievable bore stability.



Sterling's revolutionary *Conformatic* piston already has been accepted and is now being used in a number of America's finest and most popular passenger cars.

STERLING'S CONFORMATIC PISTON WITH INTRA-CAST STEEL LINED GROOVES

prevents frictional horsepower loss, reduces oil consumption to an absolute minimum, and prolongs engine life up to 400%. *Intra-Cast* and *Conformatic* are registered trade names of STERLING Aluminum Products Inc.



NEW MANUFACTURING FACILITIES FOR STERLING ALUMINUM

120 acres! Completely new automated plant at the confluence of the Missouri and Mississippi Rivers

STERLING

ALUMINUM PRODUCTS INC.

ST. CHARLES, MISSOURI

SA-1

WORLD'S LARGEST MANUFACTURER OF ALUMINUM ALLOY PISTONS

Drilling power at your finger tips to speed production, cut costs

A new "one-two punch"—lots of power and little weight—makes Keller Tool portable air drills the answer to most hand drilling applications.

The 11A-2 model offers a complete torque and speed range—from 600 to 17,000 rpm. Newly designed air intake and exhaust increase power, improve motor efficiency and muffle noise. Light weight is teamed with added power through a small body diameter of only $1\frac{1}{2}$".

Other important air motor features include interchangeable gears, spindles and chucks which afford quick conversion to various jobs; side air intake and large exhaust ports providing more efficient operation; one-shot lubrication with flush-type fitting; capacities up to $\frac{5}{16}$".

For complete information on these versatile, new Keller Tool air drills, write for descriptive bulletins.

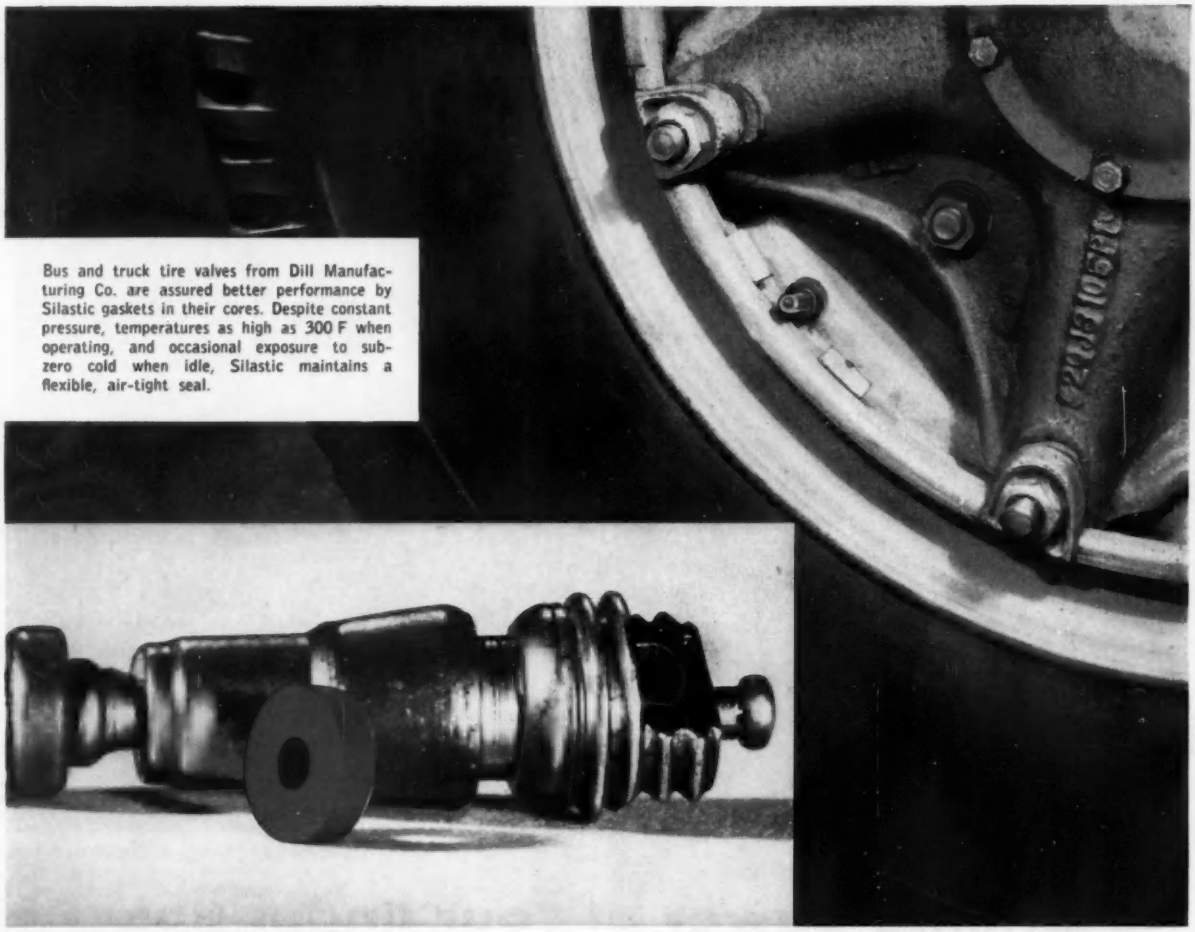
NOW—EASY CLOSE-QUARTER DRILLING

Drilling in those hard-to-reach places is easy with the new Keller Tool 11G-2 Series angle air drill. Well balanced for easy handling, this drill has a heavy-duty spiral bevel gear drive. Like the 11A-2 model, it is also powered by a No. 2 air motor.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois



Bus and truck tire valves from Dill Manufacturing Co. are assured better performance by Silastic gaskets in their cores. Despite constant pressure, temperatures as high as 300 F when operating, and occasional exposure to sub-zero cold when idle, Silastic maintains a flexible, air-tight seal.

SILASTIC
SILICONE RUBBER

resists heat, cold, high compression

For resistance to fuels, oils and solvents, specify Silastic LS

Where conditions are too severe for organic rubber, yet rubbery properties are needed, try Silastic*, the Dow Corning silicone rubber. Silastic stays resilient from —130 to 500 F, and has very low compression set at extreme temperatures. It resists moisture, weathering, most hot oils and has high dielectric strength. Leading rubber companies offer Silastic as calendered, extruded and molded parts in either solid or sponged form.

Get latest data on Silastic. Mail coupon today

Dow Corning Corporation, Dept. 9120
Midland, Michigan
Please send me latest data on Silastic

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Typical Properties of Silastic for Molded Parts

• Temperature range, °F	—130 to 500
• Tensile strength, psi	600 to 900
• Elongation, %	150 to 300
• Compression set, %, @ 300 F	15 to 40
• Hardness range, durometer	20 to 90
• Dielectric strength, volts/mil	400 to 500
• Oil resistance	Dependent on type of oil

*T.M. REG. U.S. PAT. OFF.

If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

STACKPOLE
Quick-Filming
BRUSHES
One of the most outstanding advances in aviation brushes since Stackpole's wartime production of the first long-life high-altitude brushes.

NOW! Immediate HIGH-ALTITUDE BRUSH PERFORMANCE

. . . without any sea level filming run

Stackpole Aviation Brushes in a new line of Quick-Filming grades give *immediate* and highly satisfactory high-altitude performance. No break-in filming run is needed. Just seat the brushes properly and they're ready to go.

Best of all, immediate filming for service at higher and still higher altitudes has *not* been obtained at the expense of any other essential phases of brush performance. Note these features:

EXCELLENT COMMUTATION from no load to full load; from minimum speed to overspeed; and through rapid transitions from earth surface to high altitudes, Stackpole Quick-Filming Brushes assure smooth, well-filmed commutators without grooving.

LONG LIFE—Seldom if ever will it be necessary to obtain a waiver on high-altitude brush life specifications.

GREATER STABILITY over a wide range of operating conditions. You'll be pleasantly surprised with the relative stability of Stackpole Quick-Filming brush temperature, field current and commutation under speed, load, temperature and altitude variations.

LOWER, MORE STABLE BRUSH TEMPERATURES—Vastly improved commutation combines with exceptionally low friction coefficient to reduce and stabilize brush operating temperatures materially.

CONTACT DROP *vs Current Density curve that approaches a straight line relation*—This feature helps distribute brush wear uniformly, counteracts selective wear on multiple-brush installations. A wide range of values is available to meet specific application needs.

NON-CORROSIVE, STABLE TREATMENT — The special Quick-Filming treatment of these Stackpole aviation brush grades readily lends itself to silver-soldering of rivet connections.

Aircraft Brush Inquiries Invited

Stackpole Quick-Filming Brushes are available in many contact drop levels, with various degrees of high-altitude treatment, and in types, for practically any aviation rotating electrical equipment. Stackpole brush engineers welcome the opportunity to apply them to your aviation equipment, old or new. Best recommendations can, of course, be made on the basis of complete details of the equipment and test operating conditions.

STACKPOLE
CARBON COMPANY
St. Marys, Pa.

MILESTONES IN

ACP *Granodine*® IS THE BASE

FOR SPARKLING, DURABLE PAINT FINISHES

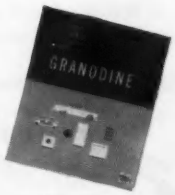
ACP Granodine provides an excellent base for sparkling, durable paint finishes on automotive equipment, home appliances and industrial products by chemically converting steel surfaces to a nonmetallic phosphate coating. It not only greatly increases the adhesion of the finish, but also provides extremely good corrosion resistance even when used in conjunction with a relatively thin and flexible paint film. Granodine coatings are easily and economically applied to steel surfaces by dipping, spraying or brushing.

AN AUTOMOBILE requires a durable paint finish that retains its beauty under all weather conditions—ice and snow, sun and rain. ACP Granodine phosphate coating provides an excellent base for such a finish—greatly increases the adhesion of the paint to the metal.

IN THE HOME, ranges, refrigerators, freezers, washers and dryers are among the many products whose sparkling finish is anchored to the metal by Granodine coating.

IN INDUSTRY, drums, materials handling equipment, machine tools and many other steel products used throughout the plant are protected by a Granodine base.

LEARN ALL ABOUT ACP GRANODINE. Bulletin 1380 describes the various types of ACP Granodine and gives information which will help you select the proper type for your particular application. Write for your copy today.



CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY, Ambler 36, Pa.

DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.

New Chemical Horizons for Industry and Agriculture

MILESTONES IN POWER PROGRESS

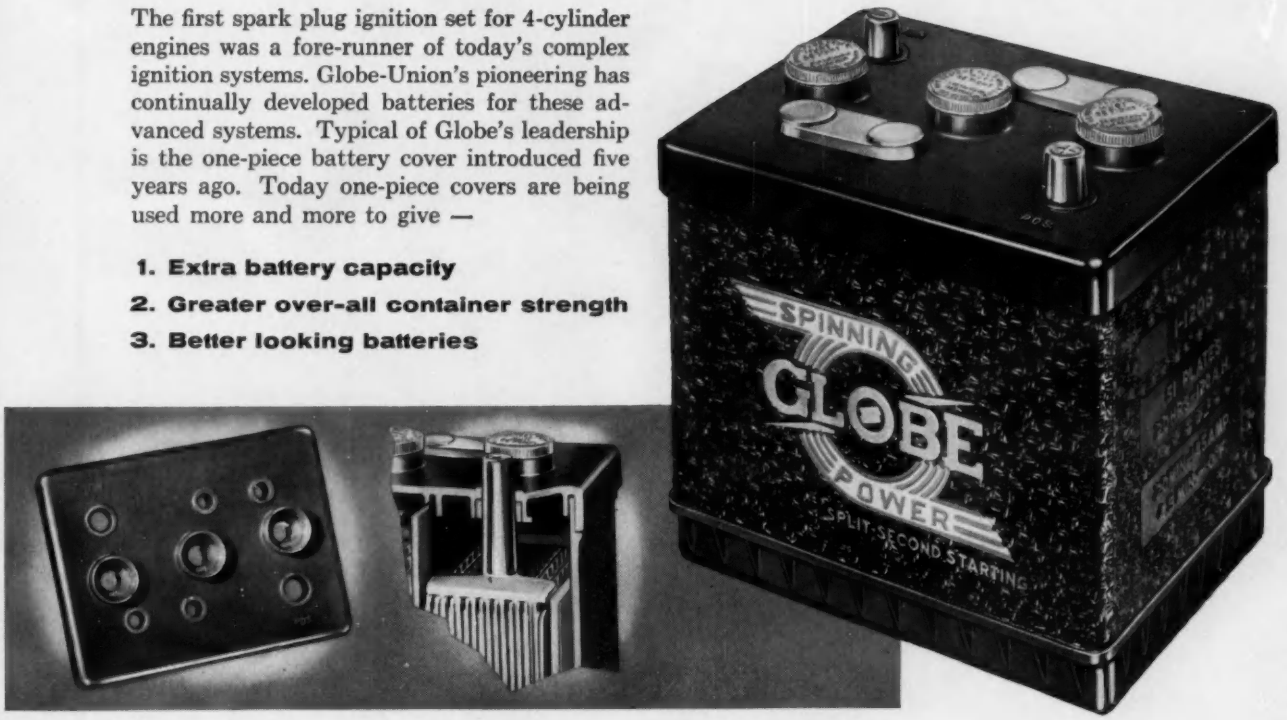
(NO. 2 IN A SERIES)

1904—First spark-plug ignition for 4-cylinder motor

1952—First practical one-piece battery cover introduced by GLOBE

The first spark plug ignition set for 4-cylinder engines was a fore-runner of today's complex ignition systems. Globe-Union's pioneering has continually developed batteries for these advanced systems. Typical of Globe's leadership is the one-piece battery cover introduced five years ago. Today one-piece covers are being used more and more to give —

1. **Extra battery capacity**
2. **Greater over-all container strength**
3. **Better looking batteries**



• Note unitized one-piece cover-case construction — brute for strength, less susceptible to damage in handling or distortion from extreme under-the-hood heat — resists vibration from road shock, protects vital battery parts — unharmed by oil and grease • Weld-sealed to case, having tongue and groove joint, triple sealed into one inseparable unit — cell partitions and container are strengthened, reinforced like a battleship to withstand heat and abuse • Another milestone in power — another first for Globe!

FASTER, LOW-COST DELIVERY!

Globe's sixteen plants are strategically located for fastest, lowest-cost shipments to all markets; thirteen (*) are producing creatively packaged dry-charged batteries.

*ATLANTA, GA., *DALLAS, TEXAS, *EMPORIA, KANSAS, *HOUSTON, TEXAS, *LOUISVILLE, KY., *MEDFORD, MASS., *MEMPHIS, TENN., *MILWAUKEE, WIS., *MINERAL RIDGE, OHIO, *PHILADELPHIA, PA., *REIDSVILLE, NO. CAROLINA, *SAN JOSE, CALIF., *HASTINGS-ON-HUDSON, N. Y., LOS ANGELES, CALIF., OREGON CITY, ORE., AJAX (ONTARIO) CANADA

SPINNING POWER
GLOBE-UNION
SPLIT-SECOND STARTING

GLOBE-UNION INC.

MILWAUKEE 1, WISCONSIN

If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!

To **engineers** who want to straighten

out the curves in their careers...

DOUGLAS TEAMWORK HELPS TO RELIEVE ENGINEERS OF BURDENSOME PROJECT DETAILS!

There are no "dead end" jobs at Douglas. As part of a crack engineering team, you'll be encouraged to use your full talents. Important assignments will give you the opportunity for greater accomplishments and the kind of future you want for you and your family. Wherever you choose to locate—in California or across the nation—Douglas offers many career opportunities including...

TOP ASSIGNMENTS FOR MECHANICAL AND STRUCTURAL DESIGN ENGINEERS!

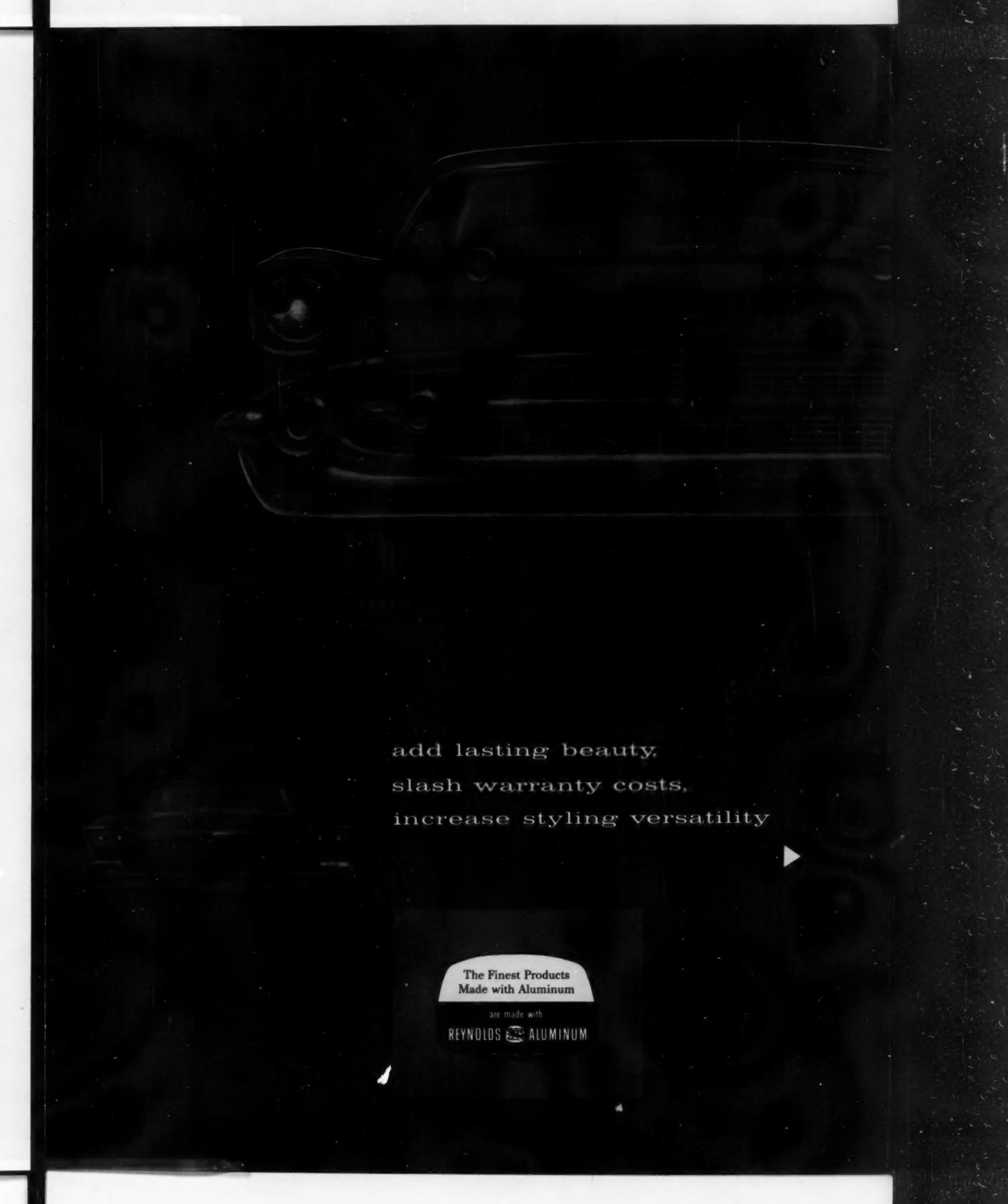
Aeronautical, Mechanical and Civil Engineers design, develop and test aircraft components from original design stage through flight test.

Go further with DOUGLAS

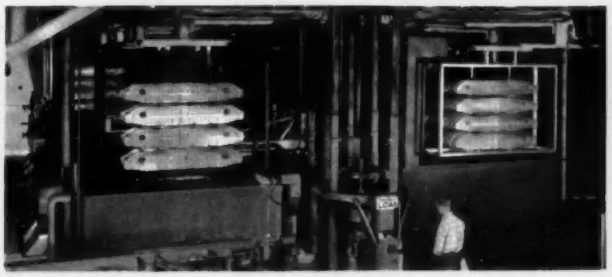
FIRST IN AVIATION

For important career opportunities in your field, write:

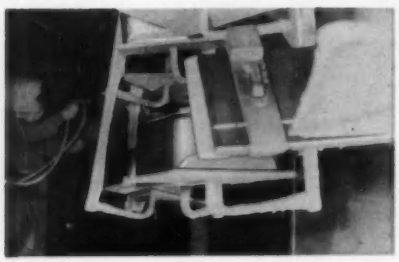
C. C. LaVENE
DOUGLAS AIRCRAFT COMPANY, BOX 620-J
SANTA MONICA, CALIFORNIA


add lasting beauty,
slash warranty costs,
increase styling versatility
The Finest Products
Made with Aluminum
are made with
REYNOLDS ALUMINUM

This new Reynolds anodizing installation can handle parts ranging from small automobile trim parts up to parts 24′ long, 12′ high and 4′ wide. This half-block long system is another new addition to Reynolds multi-million dollar finishing facilities investment...an investment that assures the automotive industry highest quality finishes on aluminum parts.

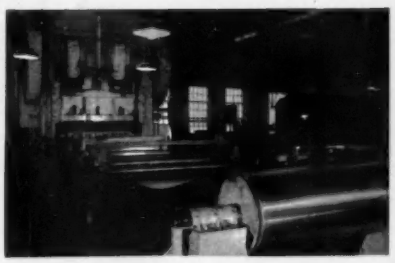


This new Reynolds automatic aluminum finishing system can finish mixed sizes and types of automobile parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



Reynolds can paint entire parts a solid color, mask and paint or do paint filling in combination with mechanical finishing to supply most desired effects.

Part of a battery of Reynolds new high speed buffing equipment used here on hood moldings for a 1957 automobile.



Part of a battery of high speed coil fed presses at Reynolds producing at the high rate necessary to meet automotive industry requirements.

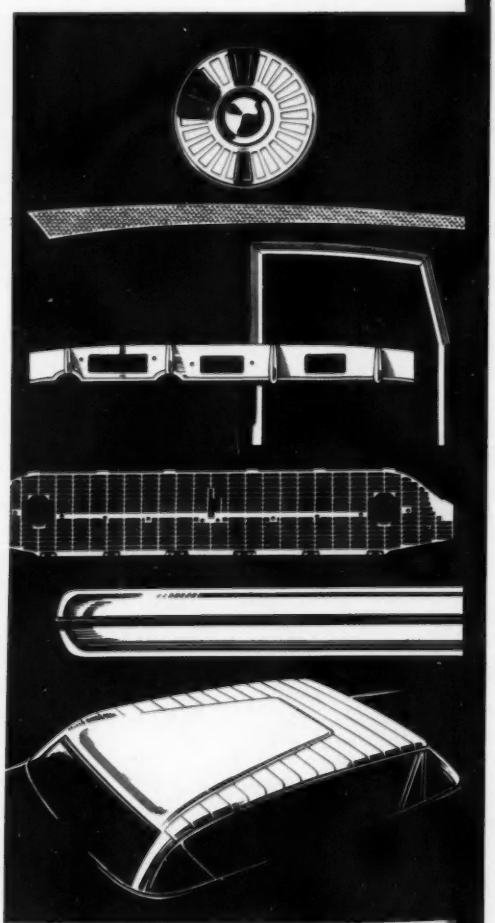
Aluminum grilles are a good example of the many ways the automotive industry is adding beauty, cutting costs and increasing design freedom with aluminum.

Aluminum grilles with gleaming clear or color anodized *in-the-metal* finishes will never chip, pit, peel, flake or rust. There's added sales appeal in this lasting beauty feature. There's also an important saving for manufacturers through *reduced warranty costs*. Flexibility in design, low cost styling changes, reduced finishing costs and saving in weight are still more advantages of beautiful aluminum grilles.

Reynolds can produce aluminum grilles by assembling extrusions, assembling roll formed shapes, stamping from sheet or by perforating specially designed extruded shapes. For lower production quantities, assembled or perforated extruded grilles offer definite cost advantages. For higher production quantities, stamped grilles offer tremendous savings in finished part costs. Whichever type you design can be produced economically and efficiently by Reynolds, and Reynolds modern finishing facilities will give your grilles the finish your latest styling requires.

The photos above are examples of the vast fabricating and finishing facilities that Reynolds offers the automotive industry. From these facilities come sales appealing *color anodized* parts with the "gleam of gold" and *clear anodized* parts with the "look of sterling". From these facilities come quality parts . . . quality controlled from mine to finished part and backed by Reynolds technological know-how in producing and fabricating aluminum. *Economical* parts, too, because of Reynolds tremendous variety of the most modern fabricating and finishing equipment.

For details on these facilities and for the assistance of Reynolds Aluminum Specialists on mill product applications or on fabricated parts, contact your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan* or *Reynolds Aluminum Fabricating Service, 2007 South Ninth Street, Louisville 1, Kentucky.*



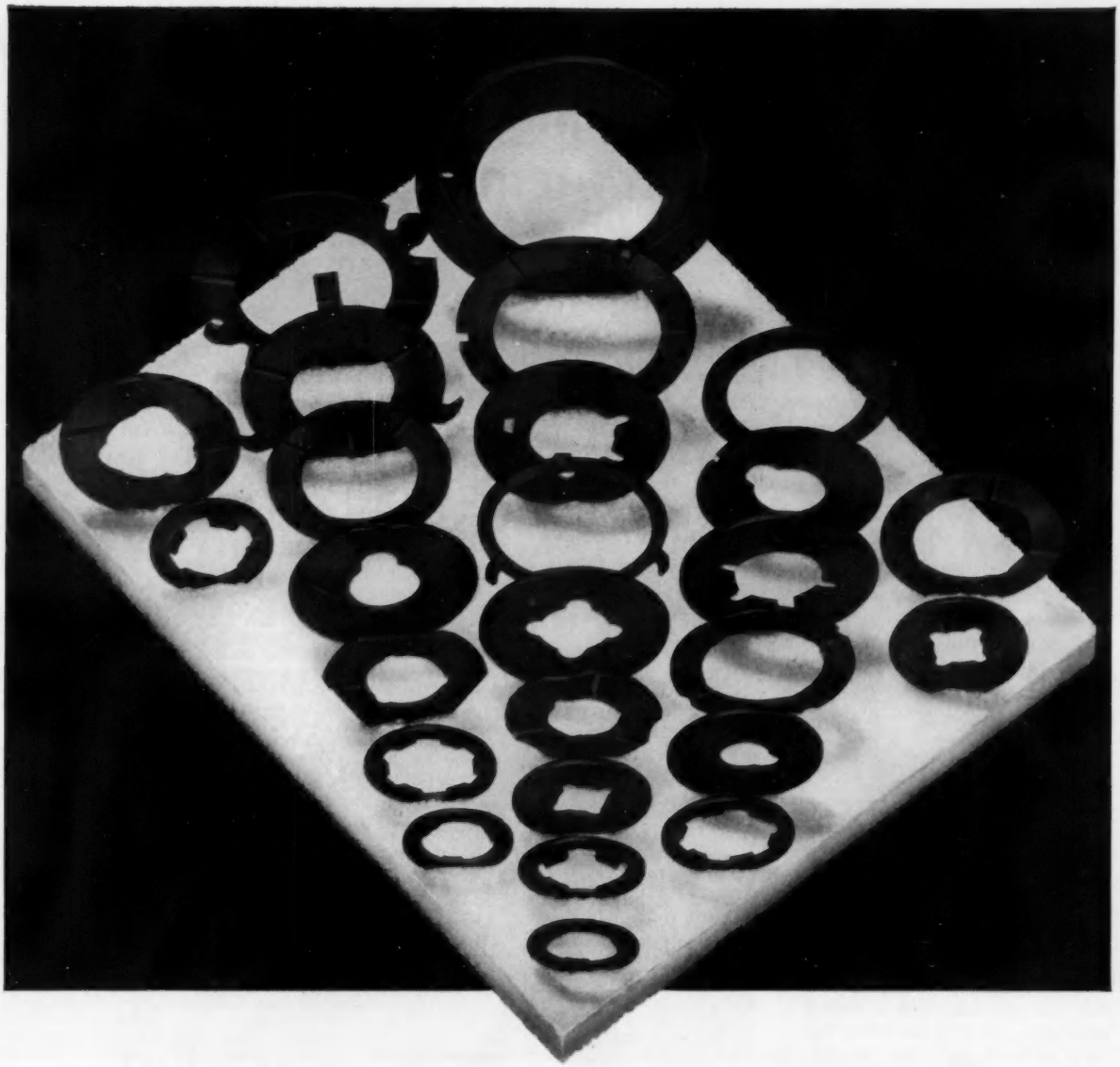
*REYNOLDS ALUMINUM—THE METAL FOR AUTOMATION**

*TRADEMARK

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

REYNOLDS ALUMINUM FABRICATING SERVICE

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING • FORMING
ROLL SHAPING • TUBE BENDING • WELDING • BRAZING • FINISHING



Variety in Precision Thrust Washer Design

Because of specially designed equipment incorporated in our manufacturing facilities, many design variations are possible in our cold-rolled thrust washers. Made of bronze, or steel with bronze on one or *both* faces, they can incorporate special holes, grooves, nibs, scallops or lugs, as required. They can be flat, spherical or special shapes, and from 1″ to 6″ O.D. Cold rolling provides exceptional hardness for heavy duty. We have large capacity and provide complete engineering service. Address:

FEDERAL Mogul
SINCE 1899

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

New high-capacity clutch facings permit design economies

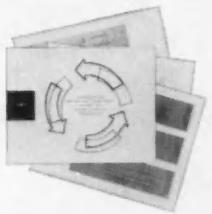
New resilient clutch facings, engineered to deliver high torque capacity under closing pressures of 400 psi or higher, have been developed by Armstrong research.

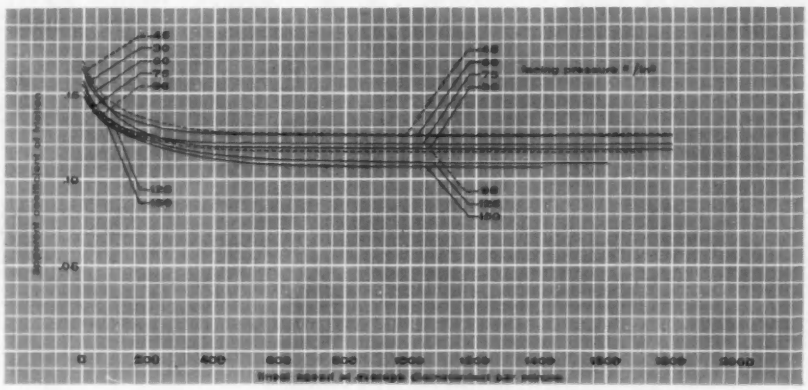
Compared with the cork-paper facings which have been an industry standard, the new Armstrong compounds have slightly higher coefficients of friction—as demonstrated by the pressure-variation curves below. The primary benefit, of course, is high torque capacity without fade losses under continued high pressure.

This high capacity makes possible a number of economies. Used on the same size plates, at the same closing pressure, fewer facings are necessary than with inorganic materials. As alternatives, the designer may specify smaller plates or lower closing pressures. Savings in friction material, in metal, and in fabrication and assembly costs can be substantial.

The flexibility of the new materials also permits wide latitude in plate design. They can be used on the waved and coned plates commonly used in current transmission designs.

For more information about these new Armstrong friction compounds, write for a copy of our new booklet. Address Armstrong Cork Company, Industrial Division, 7208 Durham Street, Lancaster, Penna.





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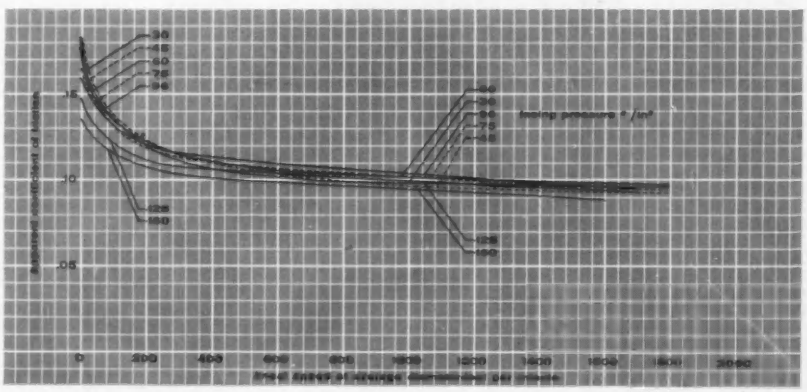


2.

These sets of curves show the coefficients of friction at varying pressures of Armstrong FM-45—one of the new materials—and a typical cork-paper clutch facing which has been operated successfully in millions of automatic transmissions. Note the marked similarity in the pattern of these curves. At engaging speed, however, the new FM-45 material (Fig. 1) has a higher coefficient of friction than the cork-paper facing (Fig. 2), and it does not rise so much as it approaches zero speed. Tests were run with a flat, plain clutch facing engaging against a flat plate. Increases in capacity can be obtained by using slotted or spirally grooved plates.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Truck body weight cut 25% thanks to strength of Nickel-Copper alloy steel

Truck bodies in the three fleets above are high strength low alloy nickel-copper steel.*

With this nickel-containing structural material, Boyertown Auto Body Works, Inc. are able to give their customers strong, corrosion-resistant truck bodies that average 25 to 40% lighter than the same size bodies made of carbon steel.

You can do the same.

High strength low alloy Ni-Cu steels provide more strength per pound . . . per dollar.

These steels show a minimum yield strength of 50,000 pounds per square inch . . . about 1½ times that of carbon steel. This means you can trim deadweight substantially without sacrificing strength, safety or service life.

High strength low alloy nickel-copper steels also provide 4 to 6 times greater resistance to atmospheric corrosion than do carbon steels. They resist shock, battering and abrasion too. And they can be readily formed and welded.

The 48-page Inco booklet *Nickel-Copper High Strength Low Alloy Steels* discusses compositions of these versatile alloys, their properties, design factors, fabrication . . . illustrates scores of applications. Let us send you a copy.

**High strength low alloy Nickel-Copper steels which meet the requirements of SAE specification 950 are marketed under various trade names by leading steel companies. Names supplied on request.*

The International Nickel Company, Inc.

67 Wall St. INCO TRADE MARK New York 5, N. Y.

INCO NICKEL

Cleveland miniature socket screws give extra strength in compact assemblies

Cleveland miniature cap and set screws eliminate the need for designing special screws to fasten parts in compact units. In countless intricate devices – servomechanisms, computers, typewriters, electronic and electrical equipment–they are used as functional parts permitting significant reduction in size, weight and cost without sacrificing strength.

Dimensions are held to very close tolerances. Accurately formed hexagon sockets insure high torque, nonslip wrenching, and maximum wrench holding power. Threads are rolled for accurate Class 3 fit and to gain extra fatigue and tensile strength. Alloy steel screws are carefully heat treated to obtain optimum of 180,000 psi minimum tensile strength.

Cleveland standard miniature screws are available from stock in both high quality heat treated alloy steel and nonmagnetic 18-8 stainless. Write today for prices and a copy of the Cleveland socket screw products folder.

RECOMMENDED INSTALLATION TORQUES IN IN.-LB. FOR HEAT TREATED ALLOY STEEL SOCKET SCREWS

Socket head cap screws			Socket set screws, plain cup point		
Diameter	NC	NF	Diameter	NC	NF
#0	—	2.0	#0	0.5	0.5
#1	3.5	3.5	#1	1.5	1.5
#2	6.0	6.0	#2	1.5	1.5
#3	8.5	9.5	#3	5.0	5.0

THE CLEVELAND CAP SCREW COMPANY

4444-12 Lee Road, Cleveland 28, Ohio

WAREHOUSES: Chicago • Philadelphia • New York • Los Angeles

NEW! Improved Vane Design

Gives Thompson Turbochargers More Capacity at Lower Speeds

Only Thompson Turbochargers have simple, straight rotor vanes which provide the economy of high-pressure supercharging at low rotor speeds. This compact, simplified design is based on the Jet Division's years of experience with air- and gas-powered air compressors. Air-foil vane sections of the turbine and compressor wheels have been developed in the Jet Division lab.

In new Thompson Turbochargers you'll find many other ways in which aircraft performance has beeen combined with automotive simplicity and ruggedness. One-piece bearings simplify maintenance . . . rugged turbine design means longer life . . . compact, space-saving design facilitates installation.

New Thompson Turbochargers are available in sizes to efficiently blow diesels from 50 to 300 horsepower. Our engineers will welcome an opportunity to show you how Thompson Turbochargers can help you achieve up to 100% increases in horsepower, with a reduction in fuel consumption.

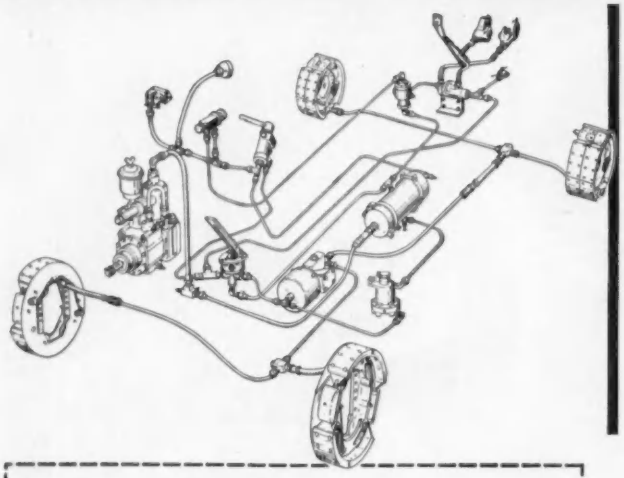
Write on your company letterhead for Booklet SJ-257, containing detailed information on Thompson Turbochargers.

JET DIVISION

Thompson Products, Inc.

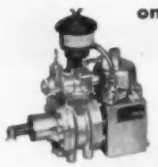
Cleveland 17, Ohio

Wagner AIR-OVER-HYDRAULIC BRAKES increase payload capacity and offer these six important operating advantages!



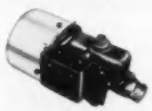
- Faster application and release of air pressure
- More efficient use of compressed air
- Greater stopping power
- Reduced friction loss
- Increased lining and drum life
- Greater stability with less preventive maintenance.

only Wagner offers...



THE ROTARY AIR COMPRESSOR

9 or 12 c.f.m. capacity—rotary motion reduces vibration, makes friction loss low, operating efficiency high, assures long life with a minimum of maintenance. Fast air recovery assures an adequate supply of air pressure at all times—an important safety factor . . . Compactly built.



THE POWER CLUSTER

converts 100 p.s.i. of air pressure into 1500 p.s.i. of unvarying hydraulic pressure for greater road safety and surer stopping power. Consists of an air-power cylinder assembled direct to a standard hydraulic master cylinder. No loss due to linkage or friction.

Wagner Air-Over-Hydraulic systems are designed to eliminate bulky, heavy, out-board rigged actuating devices and many valves and lines to permit greater pay load capacity through vehicle net weight reduction. These actuating systems also offer finer performance features for safer braking of heavy vehicles equipped with hydraulic foundation brakes.

But get the whole story on Wagner Air-Over-Hydraulic Air Brakes for yourself—*first* in economy, reliability and maximum brake safety. Send for Catalog KU-201 that describes the performance and safety features you add to the trucks you manufacture by equipping them with Wagner Air Brakes.

K57-10

Wagner Electric Corporation

6378 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U. S. A.

The complete Wagner Air Brake Line includes many types and kinds of equipment—all fully described in Catalog KU-201. Write for your copy today.

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find your Spring problem...

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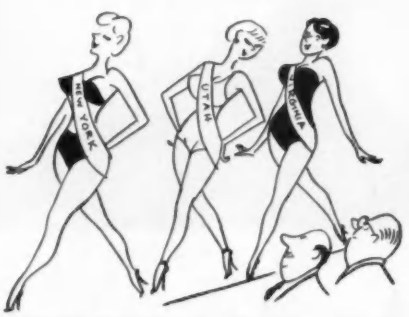
TRYING TO COIL YOUR OWN SPRINGS?

UP AGAINST SEVERE HEAT CONDITIONS?



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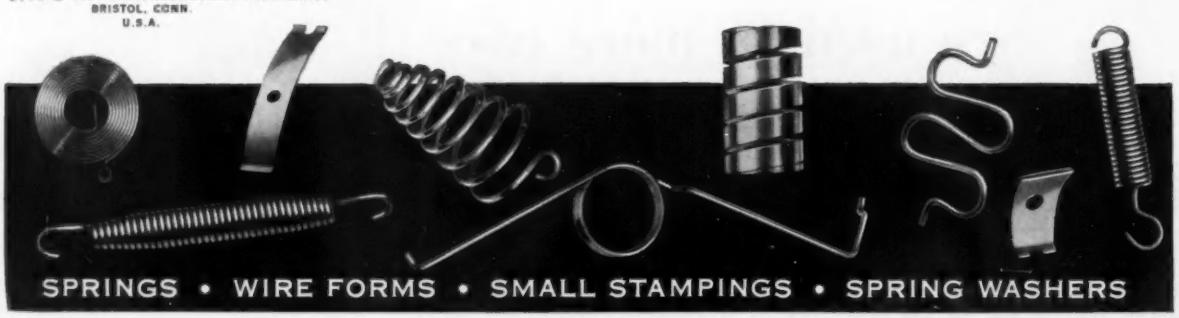

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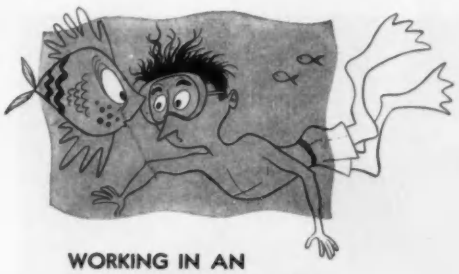
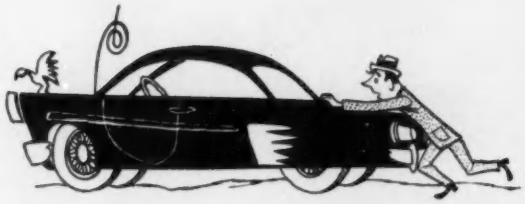


WORKING IN AN UNFAMILIAR ELEMENT?

BECOMING IRRITABLE AT ASSOCIATES?

USING TRIAL-AND-ERROR METHODS?



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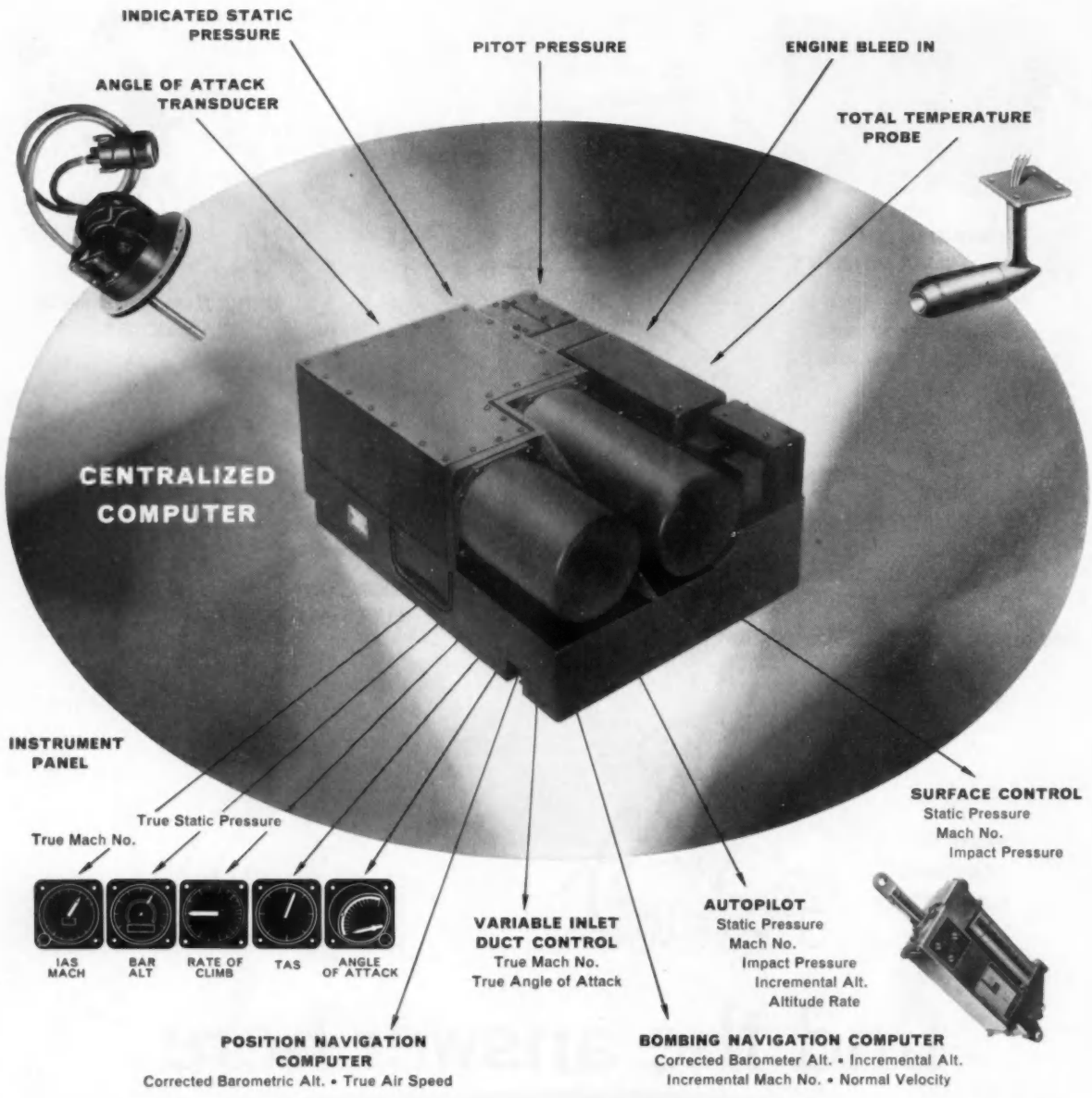

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Centralized Air Data System

This AiResearch computer system eliminates duplication of components, cutting down space and weight requirements over decentralized systems by many times. It can cover a wide area of functions while meeting the most rigid specifications in regard to accuracy and dependability. Since the great majority of its components are AiResearch products, both compatibility and reliability are assured.

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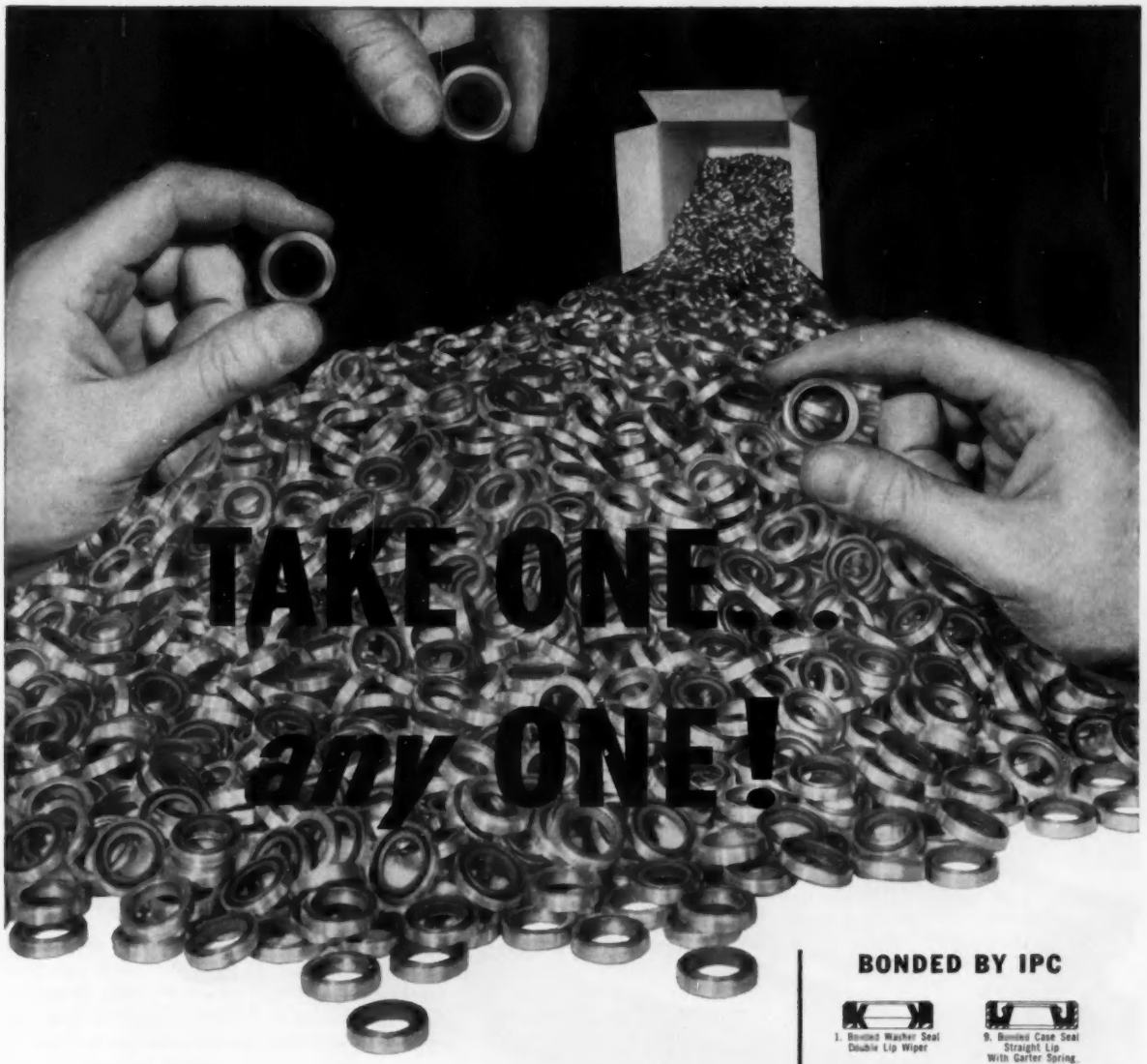

IF IPC designed these Oil Seals for your application, you can be sure that every one will give the maximum in service. That's "custom control" . . . IPC's watchword in packings or oil seal manufacture.

Specialized engineering, custom compounding, rigid manufacture and 100% inspection guarantee such results!

Your oil seals require a *custom* approach since different applications impose different demands on oil seal performance. IPC will help you solve your problems at the design stage . . . follow through by controlling manufacture and inspection. Take your toughest "nut" to IPC.

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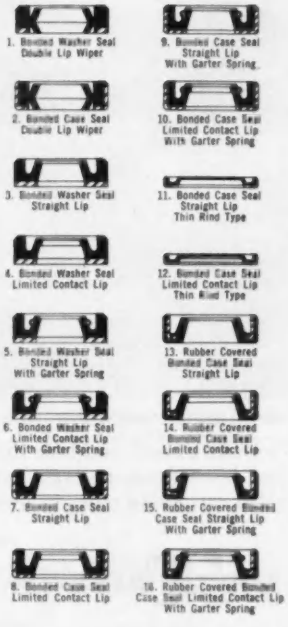
1. Bonded Washer Seal Double Lip Wiper
9. Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
10. Bonded Case Seal Limited Contact Lip With Garter Spring
3. Bonded Washer Seal Straight Lip
11. Bonded Case Seal Straight Lip Thin Rind Type
4. Bonded Washer Seal Limited Contact Lip
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
5. Bonded Washer Seal Straight Lip With Garter Spring
13. Rubber Covered Bonded Case Seal Straight Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
14. Rubber Covered Bonded Case Seal Limited Contact Lip
7. Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P4

The Great Sphinx of Giza, carved from solid granite, has withstood the ravages of many ages –

Autos aren't expected to live quite as long, of course. Yet car buyers expect "production-line" beauty and durability for the life of the car. And stainless steel, solid and enduring like the Sphinx, gives that permanent beauty and utility to critical parts and trim.

Nothing gleams and lasts like handsome, solid stainless. It's not only an extra *initial* sales advantage – it helps cars bring more in *resale*, too.

Car customers are attracted to stainless. They know it as the "no-trouble" metal that can't be hurt by fumes, road chemicals, rough weather . . . that comes bright and clean with just soap and water! And they know it does not dent and scratch like other materials.

Give them what they're looking for. *Make it better, make it stainless!* And remember that the finest stainless steels are made with Vancoram Alloys. Call your supplier for details.

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Producers of alloys, metals and chemicals

STEEL TUBING TIPS:

HOW TUBING ENGINEERS CAN HELP YOU PLAN FOR VOLUME PRODUCTION SAVINGS!

GM Steel Tubing Engineers offer cost-saving fabrication advice at the design stage!

Designers of automotive, refrigeration and other products have found that GM Steel Tubing Engineers can offer many cost-saving tips *in the planning stage.*

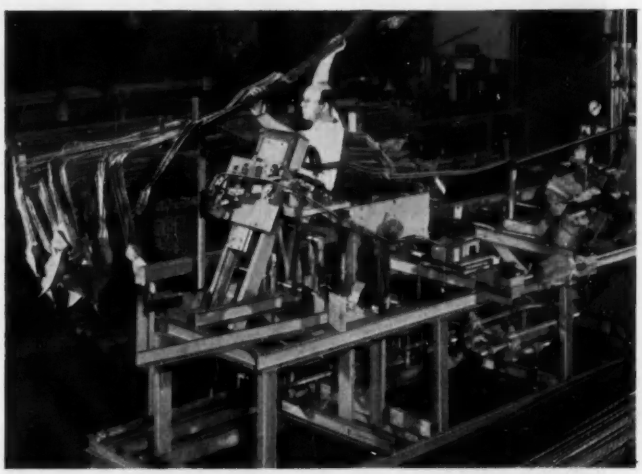
Industry standards are sometimes sufficient when designing a simple tubing application. But a review by the tubing engineer can often suggest changes which will effect greater economies in volume production.

For example, it is usually more economical to incorporate tubing of minimum thickness and diameter. However, the tubing engineer, with his knowledge of tubing manufacture, can tell you when a greater wall thickness or diameter will achieve greater economies.

And the tubing engineer's knowledge of fittings will help you at the planning stage. Based on operating conditions, he can recommend the fitting that will work best at the least cost. Keeping up with the latest tubing advances also makes it possible for him to show you how to take advantage of savings with tubing for fabricated parts and mechanical applications other than fluid or gas carriers.

The design of formed steel tubing connecting lines is another area where the tubing engineer can be of great help to the designer. Again, standards and rules may prove inadequate if you are to be absolutely sure of the most economical part to do the job. The tubing engineer can tell you how to get the greatest number of bends for the least cost, how tubing will react when formed by various methods to give you the most efficient design.

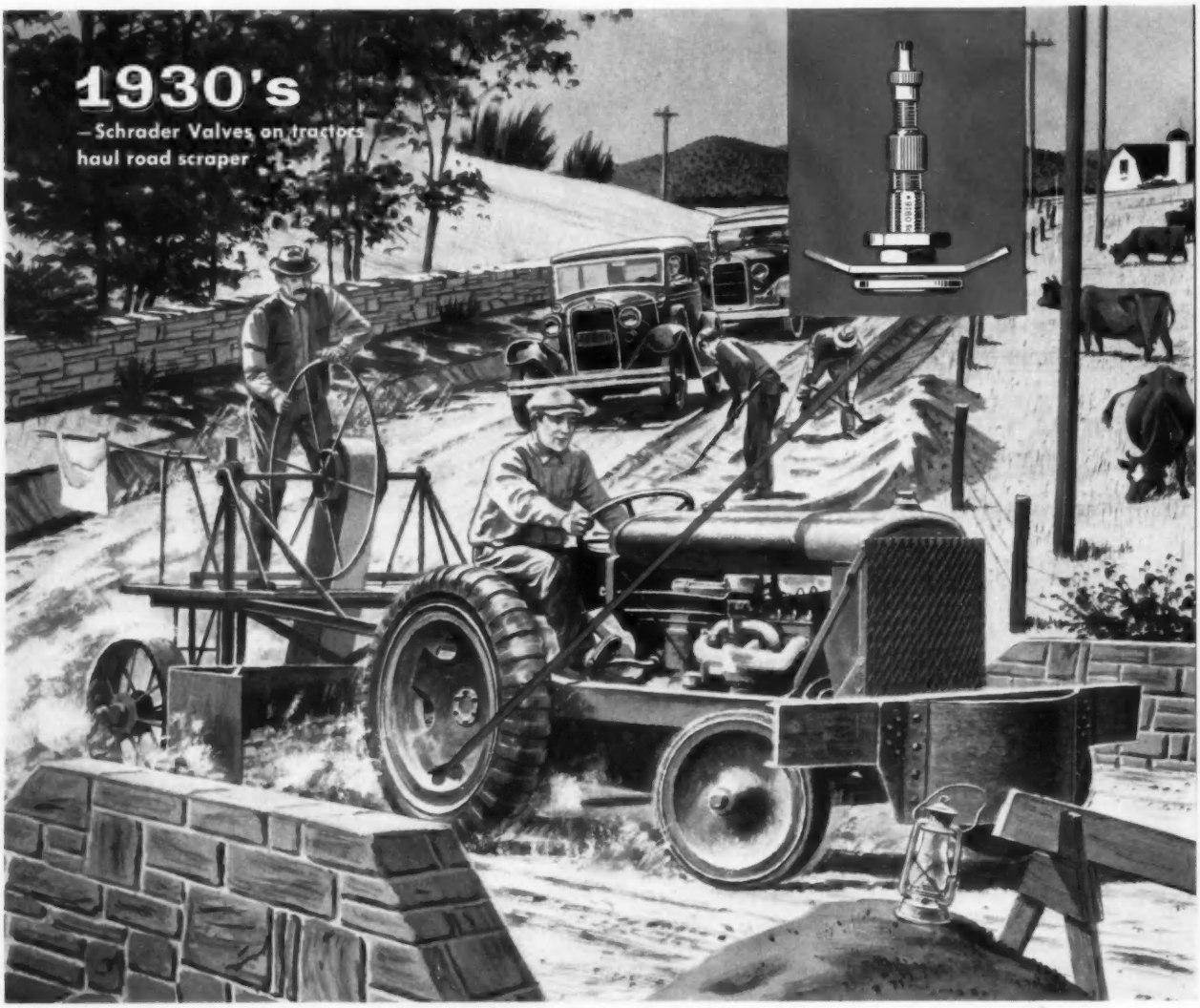
When designing any product requiring tubing, consult your GM Steel Tubing Sales Engineer *in the planning stage.* Or, for general information, write direct to: Tubing Sales Manager, Rochester Products Division of General Motors, Rochester, New York.



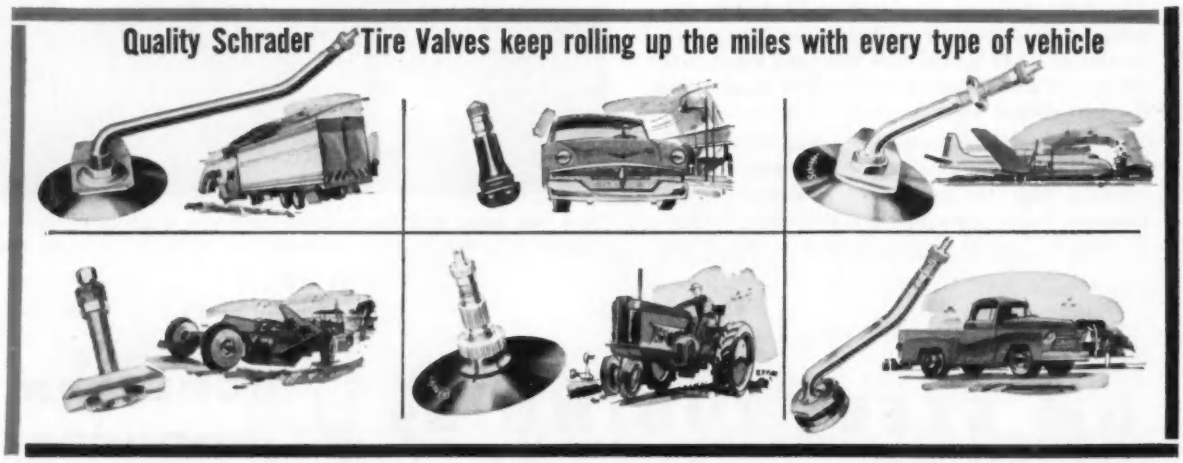
• Hydraulic forming fixtures like these at Rochester Products can be adapted to handle your requirements at minimum tooling costs. GM Steel Tubing Engineers offer you an unequaled choice of fast, cost-cutting forming equipment, let you plan production savings in the preliminary design stage.

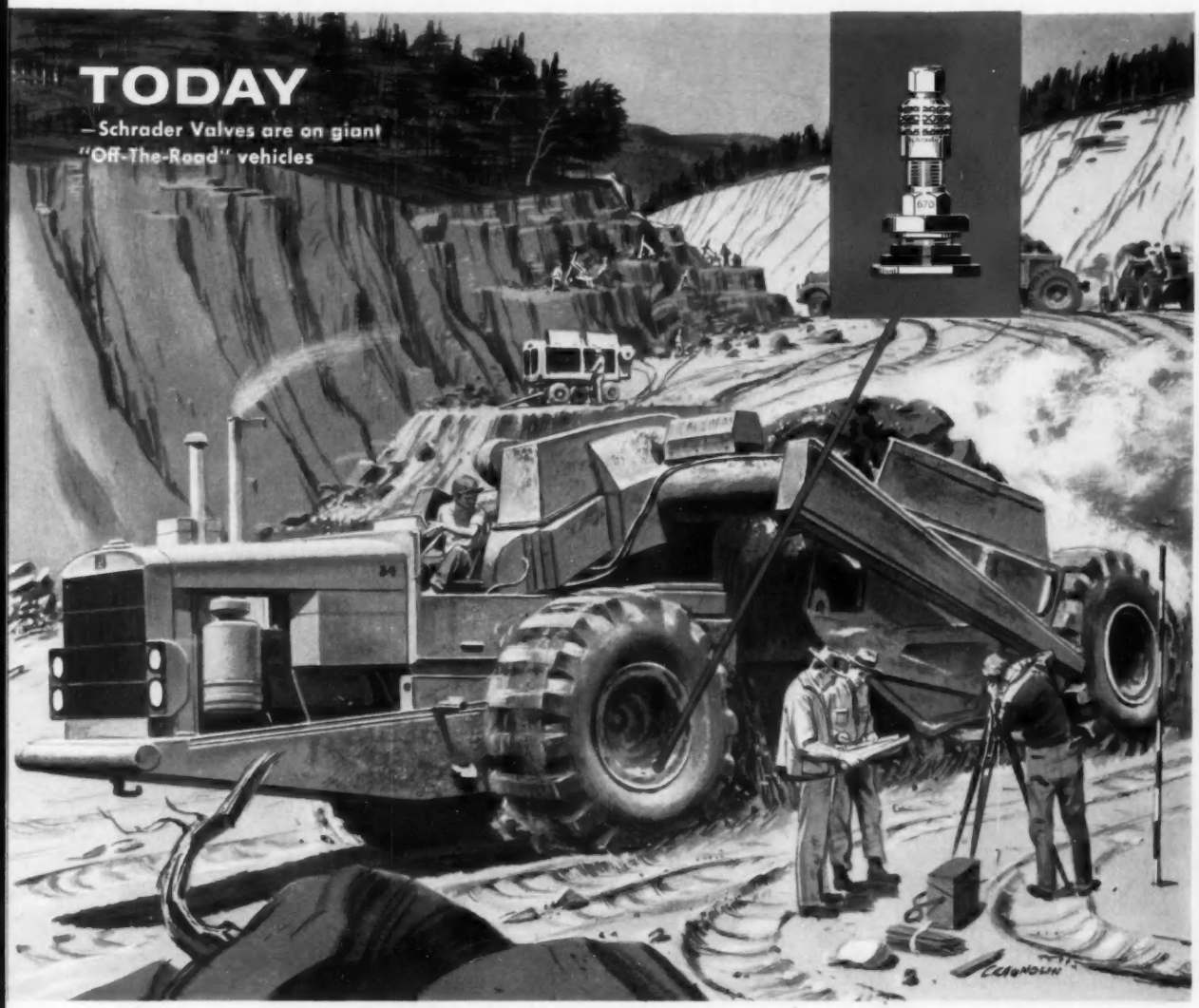
• GM Steel Tubing gives you the design flexibility of lengths up to 2000 feet. Eliminate costly joints and elbows, effect additional savings by cutting end waste.

GM STEEL TUBING by ROCHESTER PRODUCTS



OUTSTANDING TIRE





VALVE PERFORMANCE:

why can everyone count on it?

The answer is Industry cooperation. Everyone concerned with vehicles works together, pooling skills and technical research. Schrader uses this pooled experience, plus Schrader's own specialized capabilities to produce valves that have always performed so well everywhere in the world. Whether quantities involved are ten or ten million, Schrader gives expert attention to every problem: original installation, stocking, dealer replacement practices . . . service at the user level. You can count on Schrader Valves for best performance on any or all your vehicles.

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FOR ORIGINAL EQUIPMENT AND REPLACEMENT

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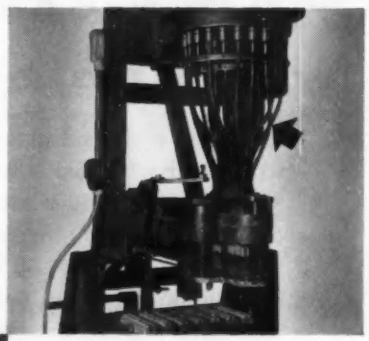
Flexible Shafts Step Up Design Efficiency

The manufacturer of this multiple spindle drill press finds that S.S. WHITE FLEXIBLE SHAFTS allow a wide range of positions for different drilling jobs.

This is only one example of the versatility . . . efficiency . . . and freedom S.S. WHITE FLEXIBLE SHAFTS are bringing to hundreds of industrial designs. The restrictions imposed by rigid shafting are eliminated. With flexible shafts you position power sources . . . driven members . . . controlled parts to better advantage. By simplifying methods of connection and adapting, costs can be reduced. Assembly is cheaper . . . alignment problems are eliminated . . . and product efficiency is often greatly improved!

Consider your own product. Chances are, S.S. WHITE FLEXIBLE SHAFTS are the simple, economical answer to your power drive and control problems. S.S. WHITE FLEXIBLE SHAFTS are noted for quality, performance and dependability. For more information and expert assistance in selecting and applying an S.S. WHITE flexible shaft to your product, just write to



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USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

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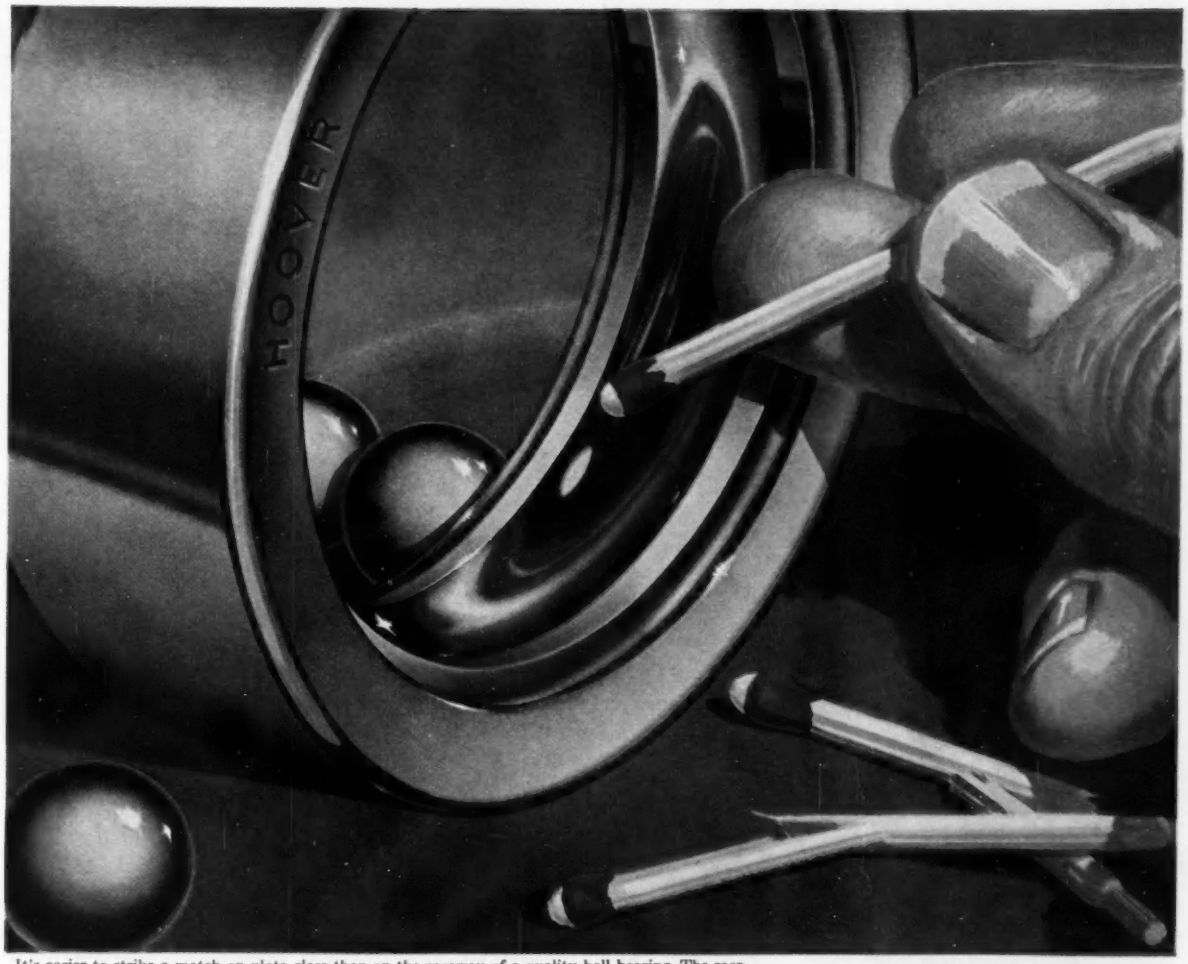

It's easier to strike a match on plate glass than on the raceway of a quality ball bearing. The raceway's smoothness makes it virtually impossible. Even so, not all bearing raceways are equally smooth.

Hoover Honed Raceways are super smooth . . . superbly finished

Bearing life—load capacity—quietness. These and other factors in ball bearing performance depend largely on the smoothness and finish of the bearing's raceway.

And that's where *Hoover Honed* Raceways pay off . . . in extra smoothness and finish. All makes of bearing raceways are ground. But Hoover Raceways are also *fully honed*. Hoover Honing, a patented process developed by Hoover, is the last word in precision finishing for raceways.

Coupled with *Hoover Honed* Raceways are matched sets of Hoover *Micro-Velvet* Lapped Balls, made to unusually high standards of smoothness and roundness. Precision throughout the working surfaces achieves superior ball bearing quality . . . assures long life and unexcelled performance.

Investigate Hoover's line of ball bearings in the light, medium and heavy series, available in a variety of types. Hoover engineers are ready to assist manufacturers with engineering and design information. Write Hoover about your problem.

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HOOVER HINTS:

Common Causes Of Bearing Failure

What makes an anti-friction bearing stop doing its assigned job? Improper lubrication, foreign bodies, soft balls or raceways, poor race concentricity, high operating temperatures and incorrect bearing selection—all are possible causes for premature bearing failure.

Common causes of bearing failure is but one of the many problems confronting users of anti-friction bearings—this problem as well as others pertaining to bearings are given concise coverage in the Hoover Handi-Book of Anti-Friction Bearings. Write for your copy today . . . it's written to help you select the right bearing for any application.

Hoover Ball and Bearing Company,
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Mail my copy of "Hoover Handi-Book of Anti-Friction Bearings."

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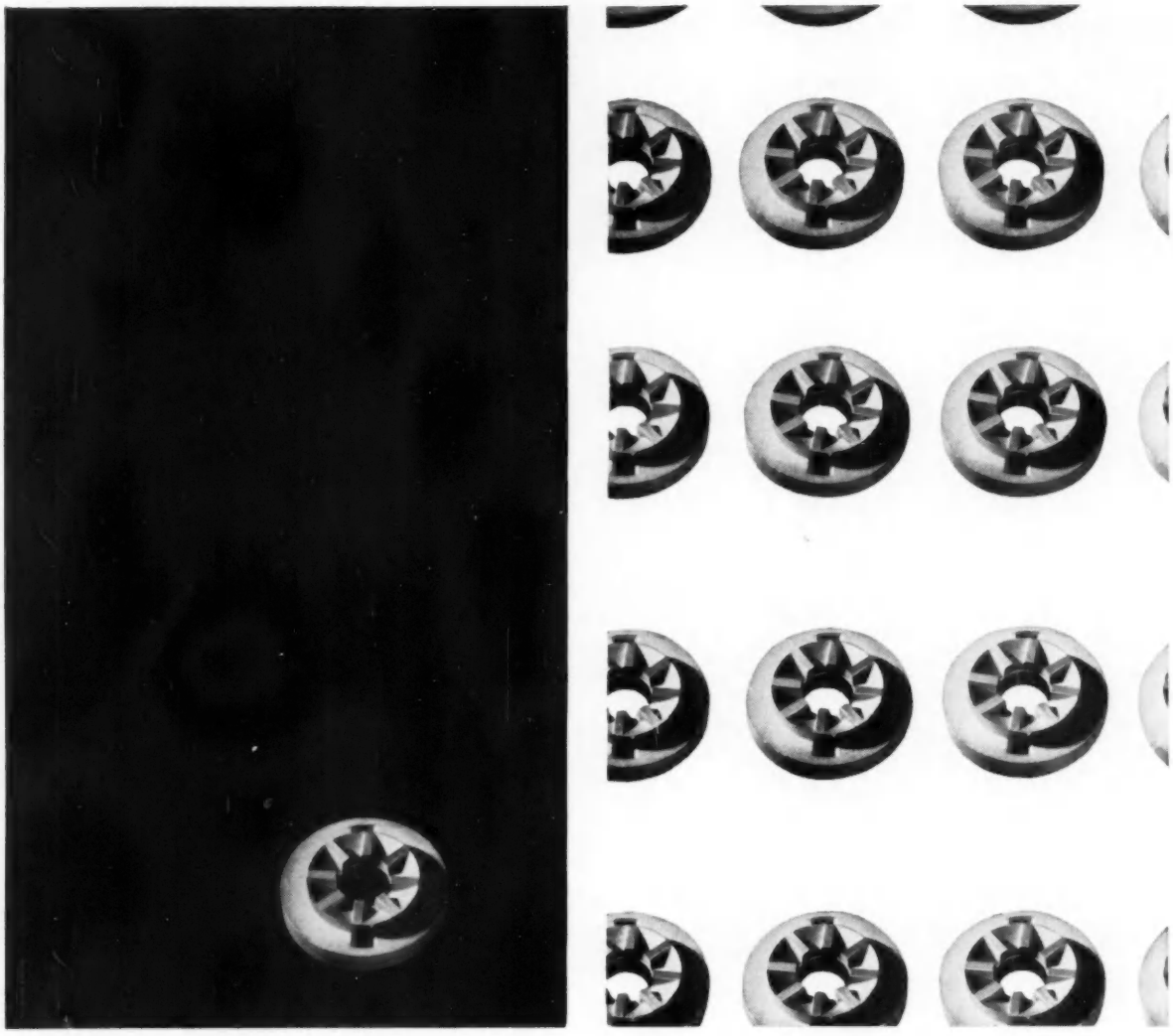


Does *volume* limit use of metal powder parts?

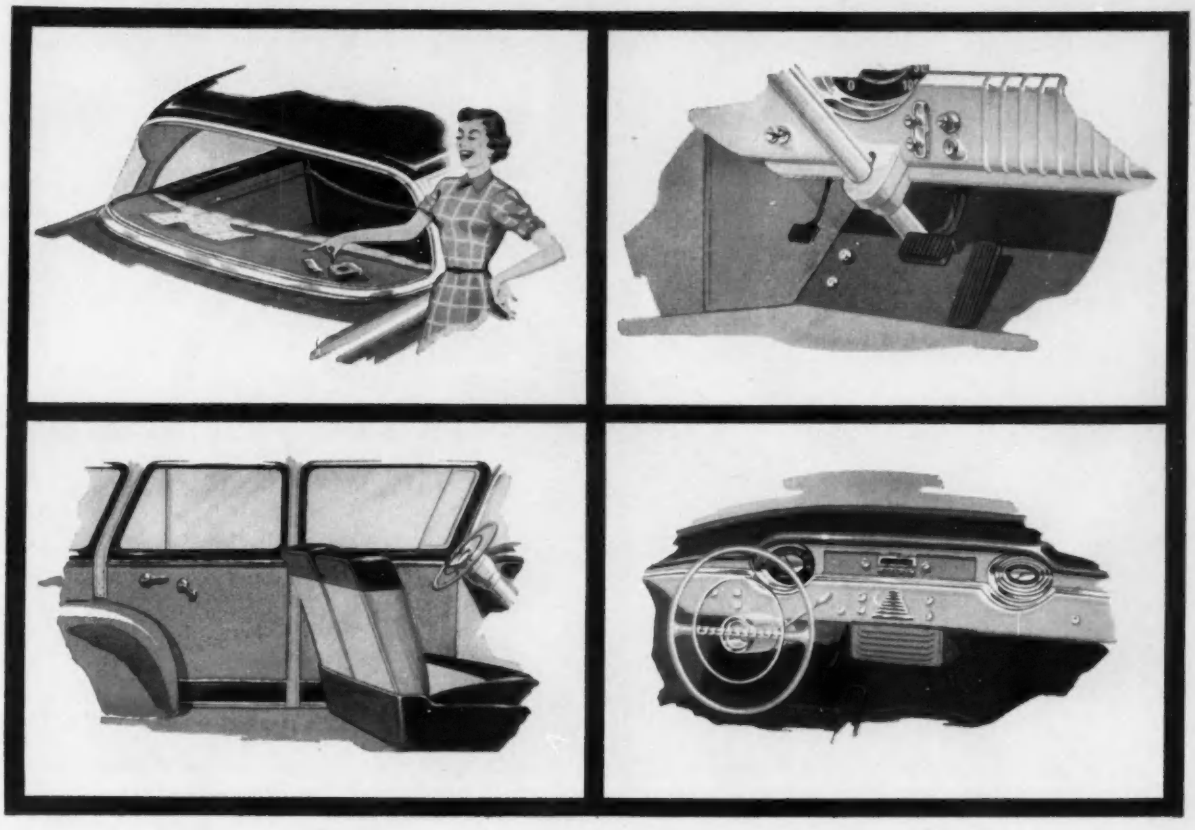
Yes, it does. For unless volume is sufficient to justify tooling costs, nobody benefits from the metal powder process. But when volume is sufficient, and the design is practical for the metal powder process, savings can be impressive. Even the most complicated part, for example, may be produced in a single press operation. Yet closer-than-ever tolerances are maintained.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

Naugatuck Marvibond



vinyl-to-metal... laminated before forming

MARVIBOND† is Naugatuck's patented laminating process that permanently bonds MARVINOL® vinyls to practically any sheet-metal *before the product is formed.* Bonded in flat sheets or coils on a continuous production basis, Marvibonded laminates can be bent, crimped, drilled, punched, or deep-drawn without fracturing the finish – without weakening the adhesive. And they're available in practically any surface effect!

Chemical, abrasion and weather resistant, Marvibonded metals provide your product with a finish far superior to paints, lacquers, varnishes, phenolic and alkyd finishes, as well as upholstered ones. Scuff-marks, fingerprints and stains wipe off with a damp cloth.

This exceptional material can be used economically everywhere that sheet metal is used . . . dashboards, window trim, door panels, kick panels, truck cabs and other interior automotive components. For technical data, samples and the names of licensed laminators in your area write to us on your company letterhead.

†U.S. Pat. No. 2,728,703

United States Rubber

Naugatuck Chemical Division

Naugatuck, Connecticut

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MicroMach extra-high-tensile stainless steel sheets up to 48" WIDE for aircraft and missile use

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

For further information write to Aircraft Steels Dept.

Washington Steel *Corporation*
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WASHINGTON, PA.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.

HERBERT W. HINCKLEY,
Assistant Chief Engineer, has more than 28 years experience in aeronautics, 24 of them with Convair. He is responsible for directing the activities of the Product Design, Testing, Project and Service Engineering, and Structure Sections at CONVAIR-FORT WORTH.

"Engineers . . . here's how we brought the B-58 from concept to reality in record time!"

"CONVAIR-FORT WORTH was first to develop a modern bomber under the new Weapons System Management concept. This enabled us to save more than two years' time in bringing the supersonic B-58 Hustler from concept to reality.

"As Weapons System Manager, CONVAIR-FORT WORTH cooperated with thousands of other engineers in electronics and related fields. This close working partnership helped greatly to accelerate the design and procurement of every major piece of mechanical and electronic equipment on the B-58.

"We integrated design requirements for this equipment with those of the aircraft, and design of both with the necessary production requirements — materials, tooling, methods and plant facilities. *This carefully controlled, highly integrated program brought the B-58 to the flight test stage in record time.*"

Many of America's most capable engineers, working on the B-58 project, have demonstrated what we mean when we say, "Your future is at CONVAIR-*FORT WORTH.*" If you are a qualified engineer with creative talents and vision, we need you NOW! With more than 50 Air Force contracts, we can offer you long-range security and diversity of activity.

You'll enjoy living in an exceptionally friendly community with countless educational, cultural and recreational facilities — with adequate housing in all price ranges only minutes away. No state sales or income tax. For greater career opportunity — for your future's sake — write today to: Mr. H. A. Bodley, Engineering Personnel.

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FORT WORTH
FORT WORTH, TEXAS
CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

HELIARC Welding
finds satellite jobs are right in its orbit

Welding together sections for an earth satellite, under the most exacting specifications, may not be your particular problem. But if welding light-gage, hard-to-weld metals is slowing up your production—LINDE's HELIARC Inert Gas Shielded Arc Welding, using LINDE Argon as a shielding gas, may be just what you've been looking for.

HELIARC Welding is LINDE's method for high-speed fusion of commercial metals, automatically, or manually in all positions. LINDE Argon, guaranteed 99.99% pure, protects the weld. It is readily available, in cylinders or in bulk, from convenient sources all over the nation.

Get more information about HELIARC Welding and LINDE's other modern welding methods. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. SA8. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

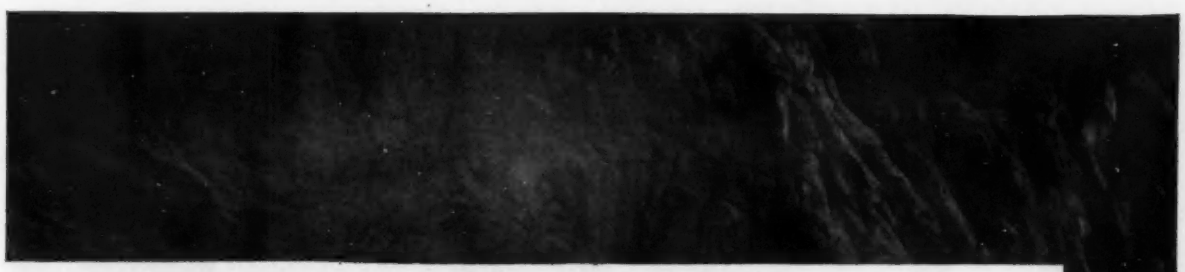
FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!

Shells of the Earth Satellite, Project Vanguard, are made of .050-in. magnesium alloy sheet, containing small amounts of aluminum and zinc. The two hemispheres are manually welded together (above), with a cover ring, by HELIARC Welding, a LINDE development utilizing an argon-shielded tungsten arc. Brooks & Perkins, Inc., are the fabricators.

Linde TRADE-MARK

UNION CARBIDE

The terms "Linde," "Heliarc" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



you can meet any lubrication specification if you

BLEND WITH ENJAY PARANOX®

(DETERGENT-INHIBITOR ADDITIVES)

Blended with Paranox, lubricants can be compounded to combine *both* minimum wear and maximum engine cleanliness characteristics. That's why more and more refiners and blenders are relying *exclusively* on Paranox in formulating lubricants for heavy duty equipment and all engines that are subjected to tough operating conditions.

Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Contact the Enjay Company today.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

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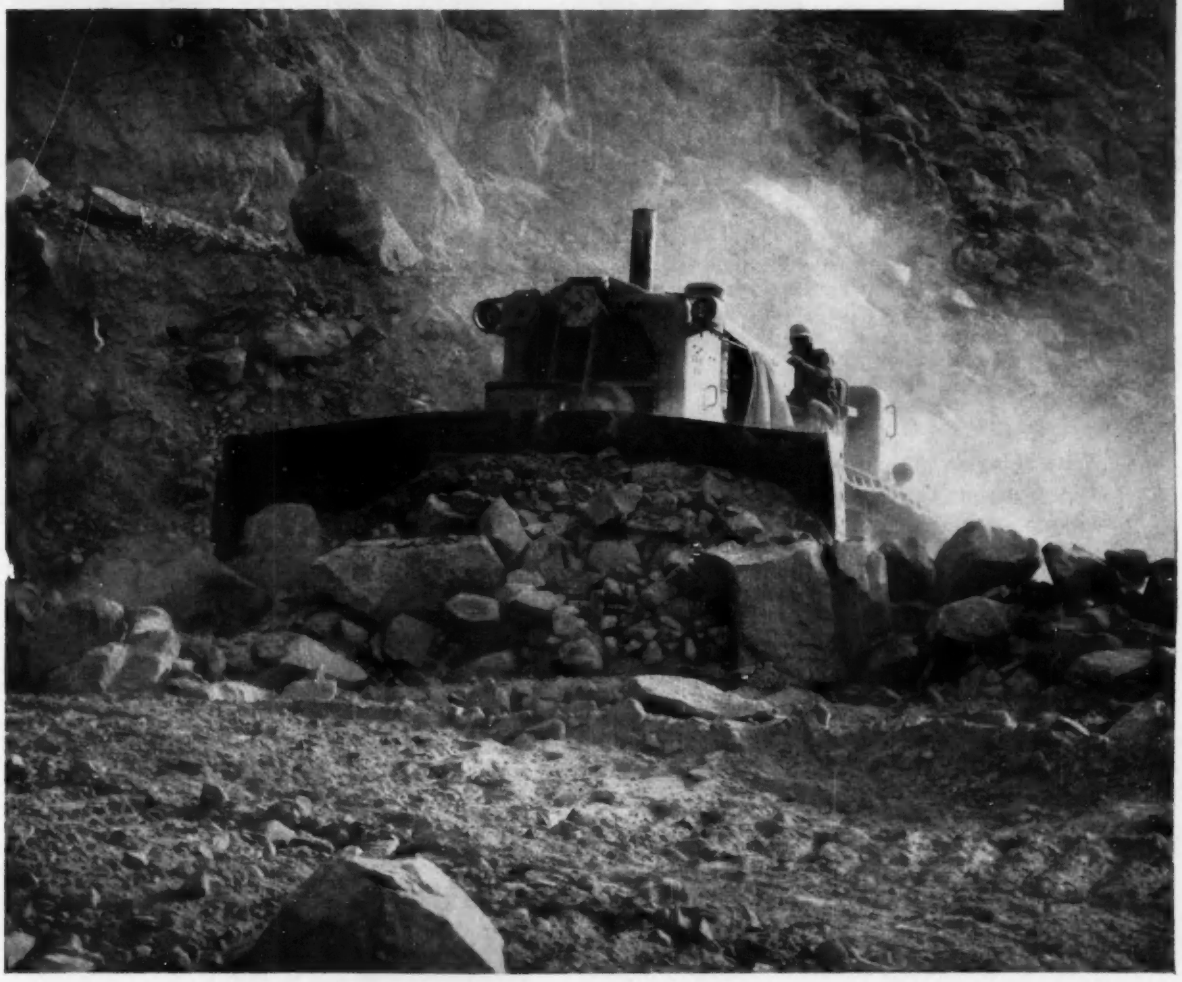


NEW

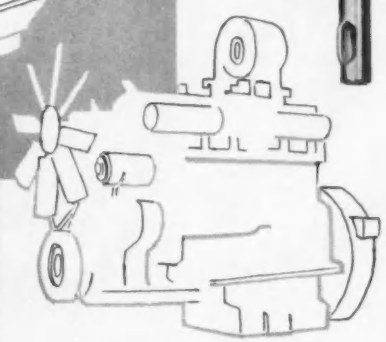
Tachometer Take-Off

...for VEEDER-ROOT Rev-Counters

With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:



Everyone... Can Count on

VEEDER-ROOT

INCORPORATED

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BRIDGEPORT ALUMINUM EXTRUSIONS ADD TO THE FUN!

Selling soft ice cream is more than a matter of having plenty of vanilla and strawberry and chocolate on hand! People—even little people—are attracted to this ice-cream truck built by Glasier Truck Body Company of Newark, N.J., because it's so attractive and clean-looking.

Gleaming Aluminum Extrusions by Bridgeport help make the difference—in appearance and extra sales. Standard and special Bridgeport shapes are used in this truck, as structural members and trim . . . and their easy-to-clean, corrosion-free beauty will last for the life of the truck.

Bridgeport Extrusions were selected for this use because of their close, reliable tolerances, and their excellent finish. They are available in a complete line of standard shapes—and in any alloys you require. Special shapes can be made to meet your most exacting requirements. Whether you build ice-cream trucks . . . or massive trailer trucks, *it will pay you to get the whole Bridgeport story!* Call your nearest Bridgeport Sales Office for it.

NEW BRIDGEPORT EXTRUSIONS BOOK

Write on your firm's letterhead for this 130-page handbook on aluminum extrusions—alloys, properties, limits, tolerances, joining, fabricating information, etc.—including full-size drawings of Bridgeport's complete line of truck and trailer shapes. Write for your copy today.

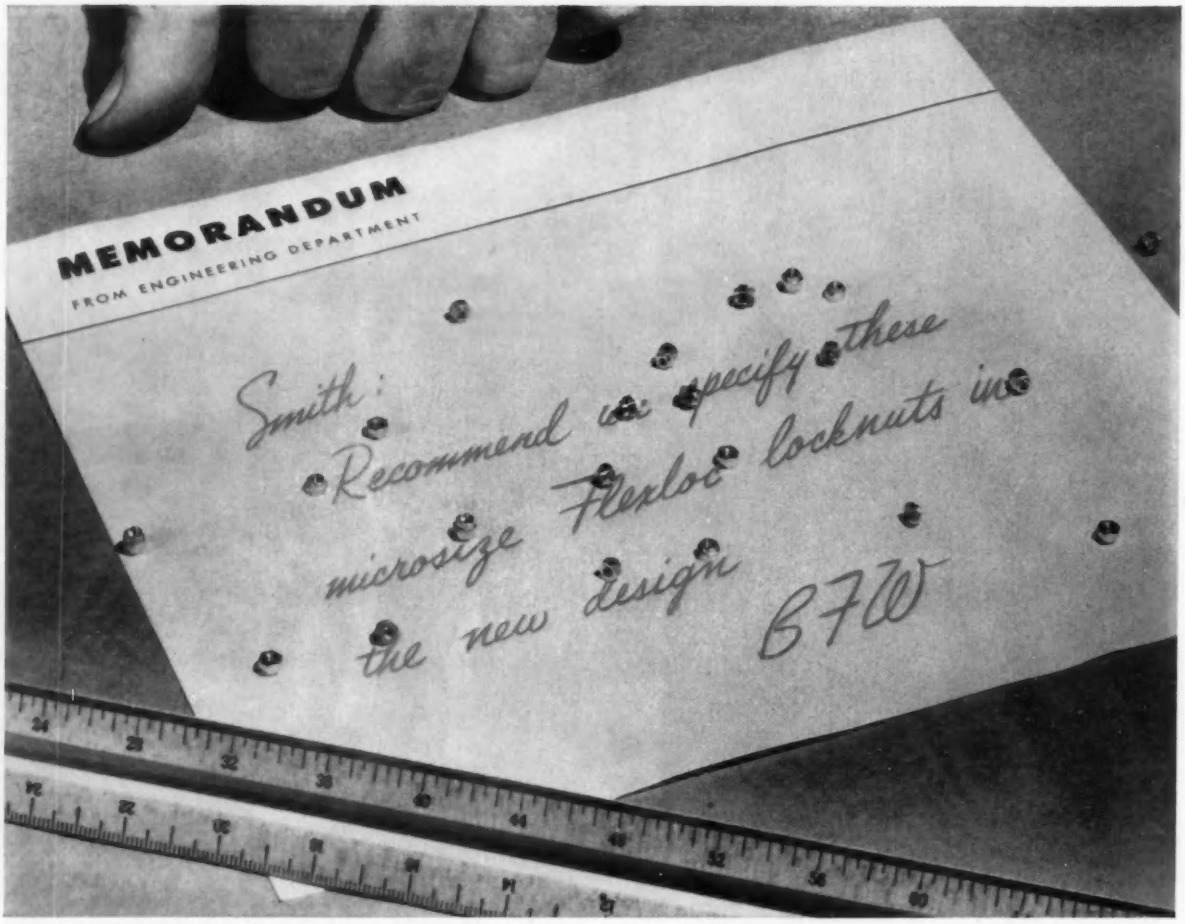
For the very newest in

BRIDGEPORT ALUMINUM

BRASS Bridgeport CO.

Aluminum Extrusion and Forging Facilities at Adrian, Michigan

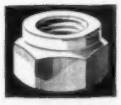
Bridgeport Brass Company, Aluminum Division, Bridgeport 2, Connecticut • Offices in Principal Cities



Microsize FLEXLOC locknuts help you design smaller assemblies and fasten them securely

SIZE	Across Flats MAX.	Across Flats MIN.	Hex. Height REF.	Across Corners MIN.	Height REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

Standard microsize FLEXLOC locknuts are available in brass (plain or cadmium plated) and aluminum (plain or chemically treated) for temperatures up to 250°F; in alloy steel (plain or cadmium plated) and 18-8 stainless steel (silver plated) for temperatures up to 550°F.



Microsize FLEXLOC locknuts save space and reduce weight in electronic equipment, instruments, servomechanisms, and other small assemblies in which weight and bulk are important design considerations. Microsize FLEXLOC locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. They permit smaller mating joints or flanges —with no loss in holding power or convenience of assembly.

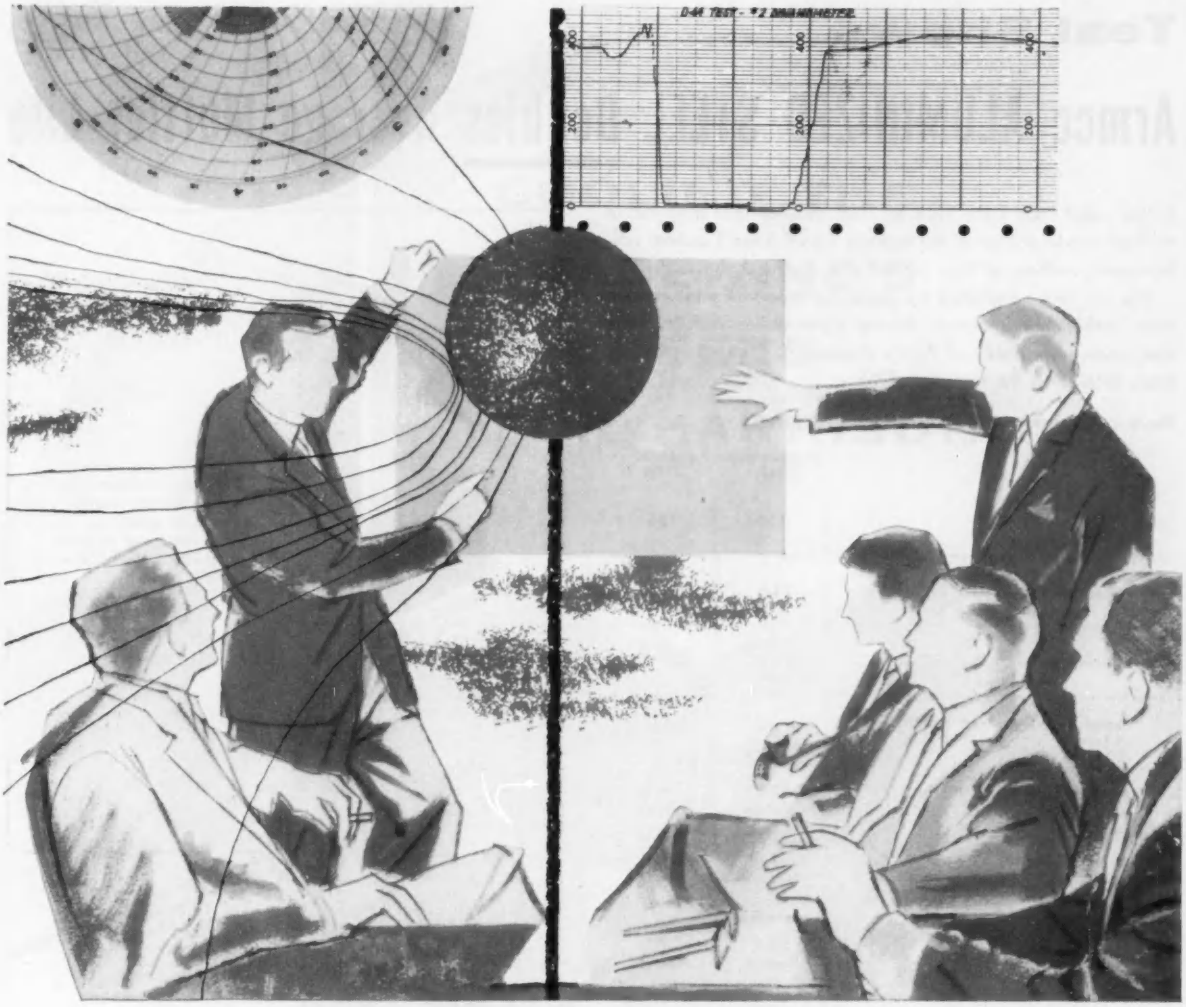
Like regular FLEXLOCS, microsize FLEXLOC locknuts are of one-piece, all-metal construction. No inserts to pop out or deteriorate; nothing to put together, come apart or get lost. FLEXLOCS lock and stay locked wherever wrenching stops. You can use them as locknuts or stop nuts. Vibration will not loosen them and they can be used many times over.

For more information on microsize FLEXLOC locknuts (or microsize FLEXLOC self-locking clinch nuts), see your local FLEXLOC distributor or write STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION **SPS**

JENKINTOWN PENNSYLVANIA



For either STOP or GO engineering...
add an American Brakeblok friction specialist to your team

TYPICAL FRICTION MATERIALS

Asbestos Based. All types of molded friction materials, including light- and heavy-duty brake linings and thick blocks, clutch facings and special products for industry.

Sintered Metal. Sintermet — sintered metallic friction materials for transmission and clutch applications in the automotive, aircraft and industrial fields.

The costly experimental work your company is planning for next month or next year may already have been done by American Brakeblok.

In one sentence, that's why it pays to call in an American Brakeblok friction specialist when considering friction material requirements. These specialists have broad experience in the use of friction materials and can often judge from their own experience which materials will or won't do the job. American Brakeblok laboratory facilities are ready to test and confirm every recommendation. For prompt service, write or phone American Brakeblok today.

American Brakeblok
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American Brake Shoe Company

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

Test Shows

Armco ALUMINIZED STEEL Doubles Average Muffler Life

Actual road tests from 1948 to 1955 showed that automobile mufflers made of Armco ALUMINIZED STEEL® Type 1 outlast carbon steel mufflers *at least two to one* on the average.

The test was conducted by replacing failed original carbon steel mufflers on privately owned automobiles with mufflers made wholly or partly of Armco ALUMINIZED STEEL. No mufflers were entered in the test after 1952.

Here are some of the significant results:

	ALUMINIZED STEEL	CARBON STEEL
Mufflers With Data Available	150	126
Failed by End of Test	37%	100%
Still in Service at End of Test	63%	0.0%
Failed Within First 24 Months of Service	4.6%	42.0%
Average Service Life of First 37% to Fail	42.6 Months	18.1 Months
Average Service Life of Failed Mufflers	42.6 Months	29.3 Months
Average Service Life Expectancy of ALL Mufflers, Including Those Still in Service at End of Test	58.0 Months	29.3 Months
Shell Failures	9%	85%

OTHER FINDINGS

Of the 56 ALUMINIZED STEEL mufflers that failed during the test, 44 were returned for examination. On mufflers with some carbon steel parts, more than 70 per cent of the failures were due solely to rusting out of the carbon steel; the ALUMINIZED STEEL parts were still serviceable.

These test results indicate that Armco ALUMINIZED STEEL in any muffler part increases not only the life of that part, but also the average life expectancy of the muffler as a whole. This was especially true of the shell, the most vulnerable component.

Since dual exhaust systems have greatly increased replacement costs, new car owners are especially conscious of muffler life. For a powerful sales advantage, consider mufflers made of Armco ALUMINIZED STEEL for *your* cars. For complete information on this special steel, write us at the address below.

Here's how a carbon steel muffler looked after only 18 months' service. Heat and products of combustion have caused the shell to fail completely.

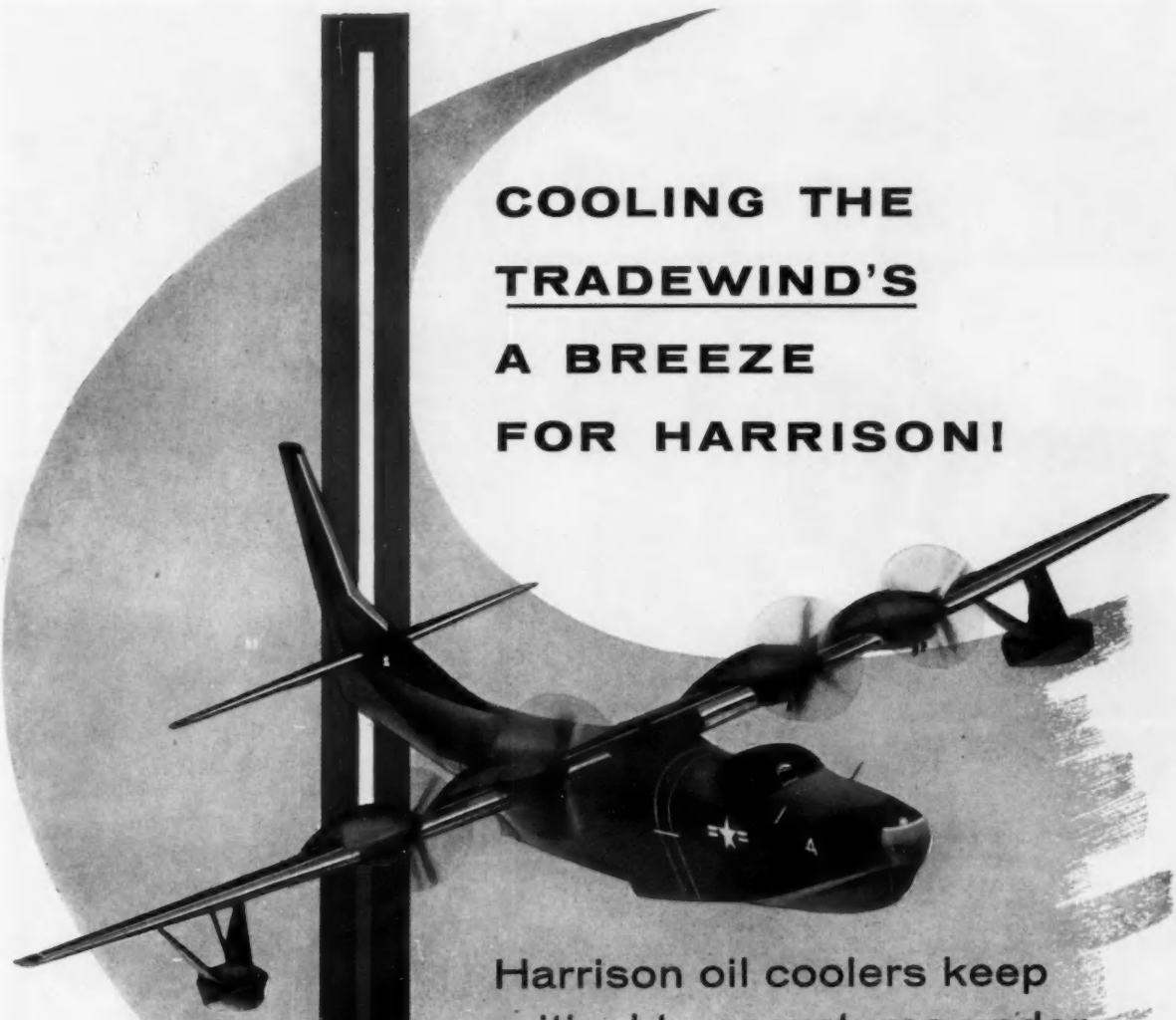
This ALUMINIZED STEEL muffler has already given 55 months' service. The shell is unbroken. The special aluminum coating is still protecting the base metal.

ARMCO STEEL CORPORATION

1077 Curtis Street, Middletown, Ohio

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation

COOLING THE TRADEWIND'S A BREEZE FOR HARRISON!



Harrison oil coolers keep critical temperatures under control on this naval transport!

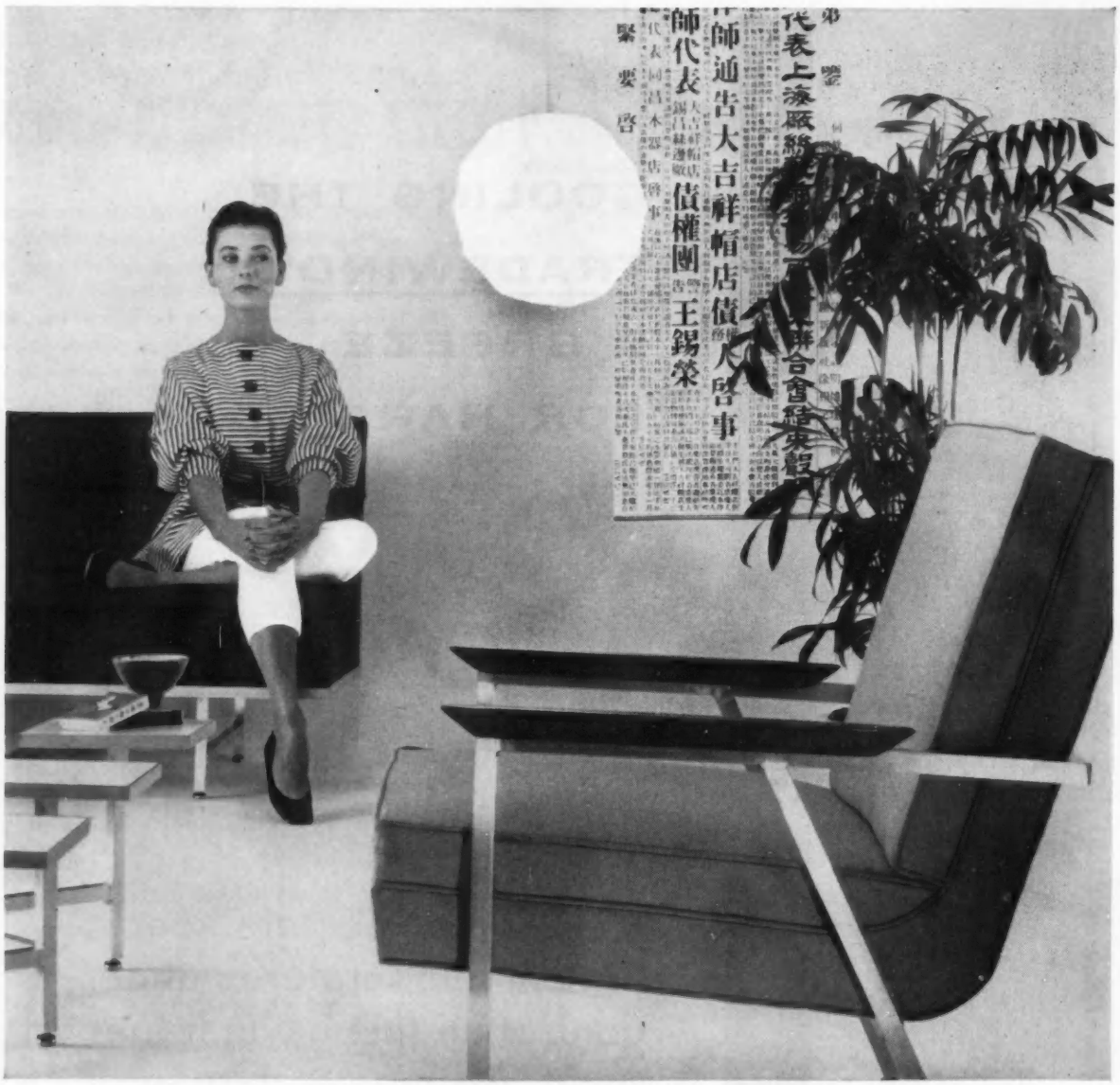
Wherever the *Tradewinds* go . . . *they're cool* . . . with Harrison! Convair's R3Y-1 is a trusty taskmaster . . . transporting troops or carrying cargo. And on the job assuring reliable performance are Harrison oil coolers. You'll find lightweight, heavy-duty Harrison heat-exchangers on all types of modern aircraft . . . in every line of defense and industry. That's because Harrison's vast experience and research in the heat-exchanger field assures complete dependability—peak temperature efficiency under the most severe operating conditions. If you have a cooling problem, look to Harrison for the answer.

TEMPERATURES MADE TO ORDER

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

GM GENERAL MOTORS



Variety—you can choose from a wide range of finishes for magnesium

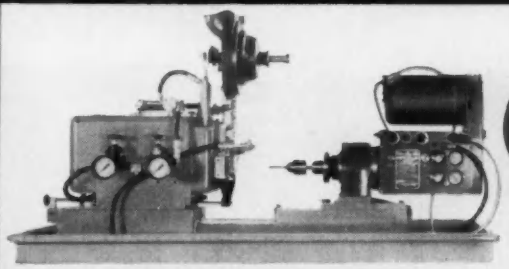
Smart, modern furniture is just one example of how finishes for magnesium are widening design horizons. Whether for appearance, protection, or a combination of both, the right finish is available. Magnesium can be painted, chemically treated, electroplated, and coated with plastic or rubber.

To meet the rigorous standards set by the aircraft industry, there are air dried and baked paint finishes with excellent adhesion, maximum imperviousness and good wear resistance. Various types of chemical pickling provide the right paint base. Anodizing provides exceptional corrosion, heat and abrasion resistance. In addition, any metal which can be applied by electroplating may be deposited on magnesium.

What about your products? If you're not making use of magnesium lightness, strength and durability—and the variety of finishes for magnesium—there's no better time to start than right now. Contact your nearest Dow sales office or write to us for more information. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1405D.

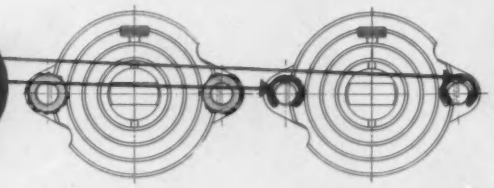
YOU CAN DEPEND ON DOW

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



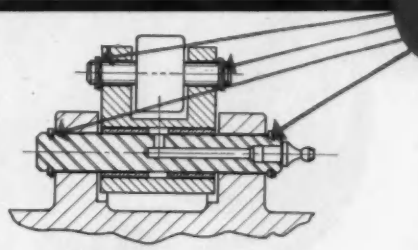
Beco Model 410 Drill and Tapper

The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



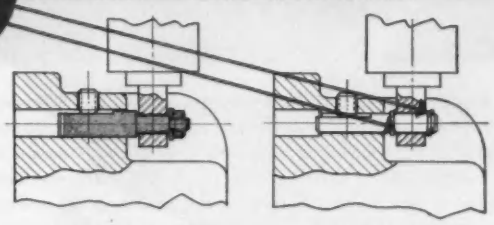
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting...plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

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TRUARC®
RETAINING RINGS
WALDES KOHINOOR, INC.
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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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SA089

AIRESEARCH TURBOCHARGERS BOOST INTERNATIONAL HARVESTER DIESEL POWER RATINGS

AIRESEARCH TURBOCHARGED *International Harvester UDT 1091 diesel is used to power this rock crushing equipment 5000 feet high at Pueblo, Colorado. Rock crushed is from 10 inches maximum to one inch minus with a 40% crush. The AiResearch turbocharger has increased the rock crusher's production by 20%, and not only boosted horsepower 20 – 30% over the diesel's previous output at that level but actually raised it over its sea-level rating. Approximately 1800 tons of rock are being crushed in eight hours by the turbocharged UDT 1091 compared with 1400 tons in an equal period with a non-turbocharged unit. The AiResearch turbocharged UDT 1091 prevents stalling under heavy loads and has operated for over 2500 hours at elevations in excess of 5000 feet with no "down time."*

AIRESEARCH C-60 TURBOCHARGER NOW AVAILABLE ON INTERNATIONAL HARVESTER UDT 1091 DIESEL ENGINE

Installation maintains sea-level output up to 12,000 feet with an important decrease in fuel consumption

AiResearch turbochargers have an outstanding record of operation in the field. Features include turbine wheels of unmatched efficiency, air-cooling which eliminates the need for complicated plumbing and ease of installation and maintenance. Thermal loading on the engine is lower by comparison than any other turbocharging or supercharging installation. Your inquiries are invited.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS					
MODEL	F-51	C-60	A-60	E-100	B-100
Diameter — in. nom.	10	11.5	15.25	15.1	15.4
Length — in.	10.5	12.9	16.75	14.7	17.1
Weight — lb.	40	95	125	112	135
Output — lb/min. (Standard Conditions)	29-51	30-60	38-60	50-100	60-100

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern styling

Clean lines. A crisp, new look. More functional. Lasting beauty. These are some of the effects modern designers gain with stainless steel—why they use more and more stainless steel every year in cars as well as appliances, housewares, furniture and houses.

To marketers, stainless steel combines the smart selling values of beauty and easy maintenance with the hard selling values of superior corrosion resistance, durability and toughness.

Stainless steel is available in countless work-saving standard shapes. It's readily machined, formed, joined, or cast.

For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 E. 42nd Street, New York 17, N. Y.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Stainless steel styling . . . first to catch the eye and quickest to capture the heart of the consumer. It combines beauty with hardness and strength to resist denting and scratching—and rust is never a problem.

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

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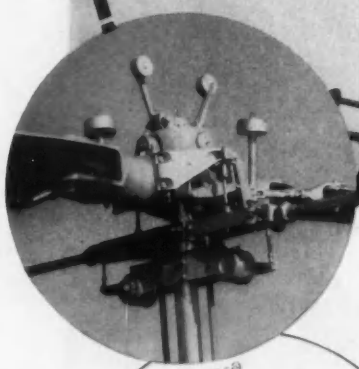
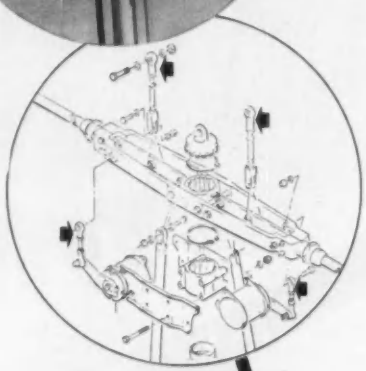




THE NEW "BELL RANGER" HELICOPTER USES HEIM UNIBAL ROD ENDS

Model 47-J is the latest helicopter to be introduced to the commercial market by Bell Helicopter Corp., and has been named the Bell Ranger. It is a four-place, executive type machine with a deluxe interior or a series of quick-change cabin arrangements for cargo, litter, and internal hoist configurations.

HEIM Unibal Rod Ends were chosen for the linkages in the carburetor heat and mixture control installations, and in the main rotor stabilizer bar assembly. The rods link hydraulic dampers to the bar, which provides exceptional stability to the flight characteristics of Bell helicopters, acting like a gyroscope and, through mixing levers, keeps the rotor plane of rotation in its pre-established flight path.

THE HEIM *Unibal* is the spherical bearing which corrects misalignment in every direction because of the universal movement of the ball — Reduces friction and lost motion in linkages — Eliminates the effects of vibration — Lowers assembly costs because of its quick and easy installation — Carries heavier loads.

Perhaps Heim can help solve — or simplify — your linkage problems. Feel free to write. Be sure each engineering and purchasing department has a Heim catalog.

THE HEIM COMPANY / Fairfield, Connecticut

Engineering the future today; highway engineer

his roadways stretch into tomorrow

With billions of dollars in federal and state money now flooding into highway construction, the first thought of many communities is "How much of that do *we* get?" But the highway engineer's overriding consideration is always "How do we do the job best and fastest?"

His is going to be a more difficult job than ever: there simply isn't enough of him to go around. Yet the shortage of men in his specialty will not persuade him to forego the bold imagination and down-to-earth practicality that are his engineering trademark all across the face of America.

As with highway planning, new automobiles take a blend of imagination, integrity and vision. In teamwork with the entire automotive industry, Carter experts in modern fuel systems are busy engineering the future today.

COMPLETE MODERN FUEL SYSTEMS

CARTER CARBURETOR

DIVISION OF acf INDUSTRIES INCORPORATED • ST. LOUIS 7, MISSOURI

How Great Lakes Steel *teems* quality

You're up on the catwalk above the pouring platform along the open-hearth pit at Great Lakes Steel. Right below, one of the giant 250-ton teeming ladles is filling another train of hot-top ingot molds.

At no step in the production of good, deep-drawing steel is control of quality more important than in the teeming operation. For defects can easily develop *unless* the entire pouring operation is done exactly right . . . the way it is at Great Lakes.

For example, these hot-top molds are designed to eliminate shrinkage cavities in the finished product. A special lining compound of graphite or tar blankets the inside of every mold to form a highly protective shield for the delicate ingot surface.

And that's only a sample of the care Great Lakes takes *every step of the way* to maintain high and uniform quality steel!

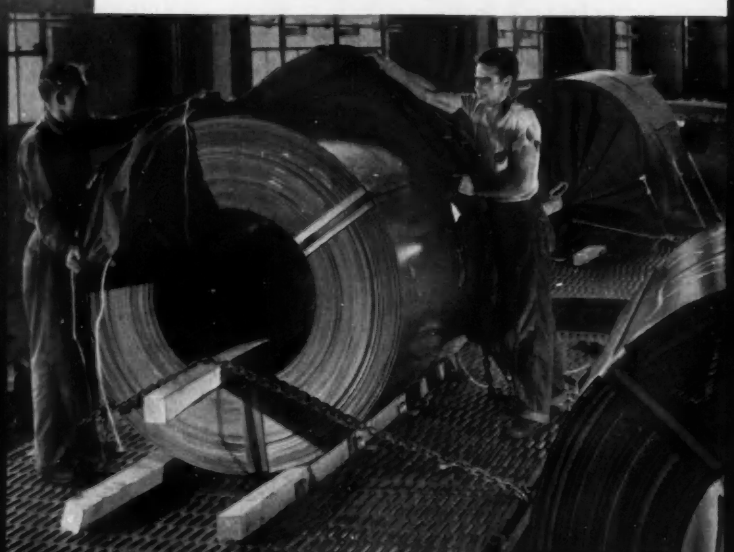
The easiest way to reach us? Simply phone our nearest representative.

GREAT LAKES STEEL CORPORATION

Detroit 29, Michigan • Division of

NATIONAL STEEL CORPORATION

District Sales Offices: Boston, Chicago, Cincinnati, Cleveland, Grand Rapids, Houston, Indianapolis, Lansing, Los Angeles, New York City, Philadelphia, Pittsburgh, Rochester, St. Louis, San Francisco, Toledo, Toronto.



BUILT-IN QUALITY of Great Lakes steel is guarded through every step to final delivery. Here shipments of flat-rolled sheet coils are covered with tarpaulins for protection.

Revolutionary *Filtronic*® Carburetor Air Filter

Product of FRAM

Pioneering Research

ONLY FRAM CARBURETOR AIR FILTERS HAVE THIS EXCLUSIVE PATENTED BUILT-IN GASKET!

This fact is important to automotive engineers interested in *protecting* their fine engines from premature wear. It is very easy to develop an air filter that will protect the engine *initially*. But, what happens after the first 10,000 miles?

Only FRAM features the patented built-in gasket shown above. This FRAM patented design absolutely prevents by-passing of dirty air—initially *and throughout* its long life. It eliminates all of the defects found in other types of sealing—such as metal to metal, metal to cork or compound gaskets and metal beads pressed against a flat plastic face. Unless these types of cartridges are replaced after servicing, in *exactly* the same position, they leak dust and dirt.

FRAM engineers designed the exclusive FRAM patented built-in gasket as an integral part of the end seal. It can never leak dirt-laden air—no matter how often it is serviced!

Add these other FRAM advantages: 99.+% efficiency, easy cartridge replacement and you'll know why FRAM *Filtronic* Carburetor Air Filter Cartridges are the finest on the market today; why nearly 50% of 1957 cars are equipped with FRAM—the air filter that obsoletes all other filter types.

FRAM Corp., Providence 16, R. I. ▪ Fram Canada Ltd., Stratford, Ont.

Only FRAM can make these statements!

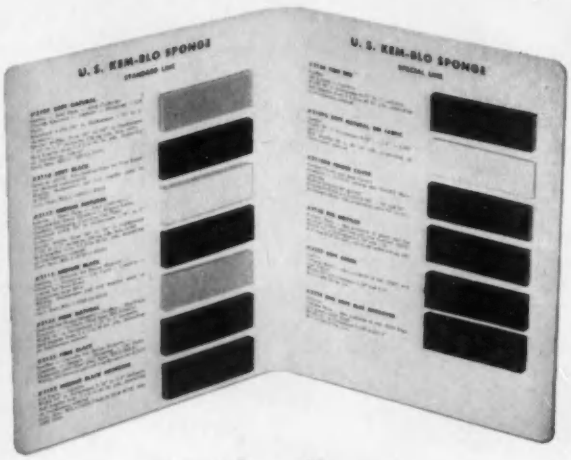
FRAM patented built-in gasket forms a perfect air-tight seal—no matter how often the cartridge is serviced, the unit is always perfectly sealed.

ALL air must pass through the filtering media. Once locked in place under slight pressure, this built-in gasket provides an absolute bond with the housing case.

New FRAM *FILTRONIC* Carburetor Air Filter is now original equipment on twenty-four 1957 engines!

Complete line of replacements for other cars equipped with a Filtronic Type Carburetor Air Filter

Send for your Handy Guide



to the finest in Sponge Rubber today!

For your ready reference—13 different actual Kem-Blo swatches included in this handy, file-fitting folder

U. S. Kem-Blo is a light... flexible... elastic sponge rubber. It will take hundreds of thousands of compressions without matting down. The perfect sponge rubber for your routine *and problem* jobs, Kem-Blo can be made to meet your specifications... for size... for performance... in any width, compression, shape and thickness. Choice of many colors, too.

Order your file-fitting Kem-Blo Swatch book *today!* Write: U. S. Kem-Blo Dept. at address below.

US RUBBER **United States Rubber**
Naugatuck, Conn

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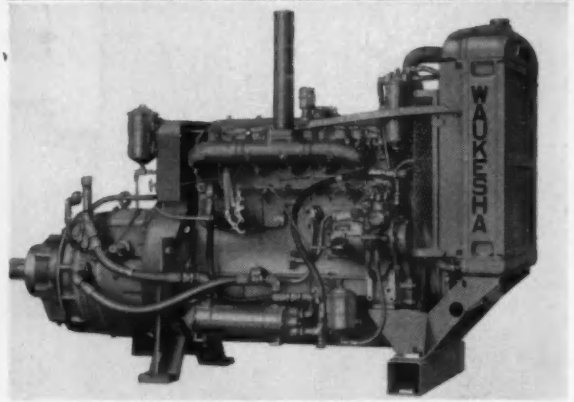

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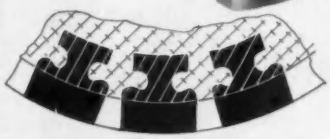
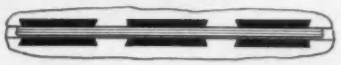


TOP RING SECTION



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Again, Zollner engineering leadership provides another great piston development to engine builders. The new Zollner "Perma-Groove" gives sensationally longer life to pistons and rings, prevents blow-by, minimizes oil consumption. The light weight segmental steel section incorporates high wear resistance in the top ring groove *plus* the advantage of cool operation. Designed especially for gasoline engine pistons, "Perma-Groove" is the quality, low-weight and low-cost companion to the popular "Bond-O-Loc" piston for Diesel engines. We suggest an immediate test of "Perma-Groove" advantages for your gasoline engine.

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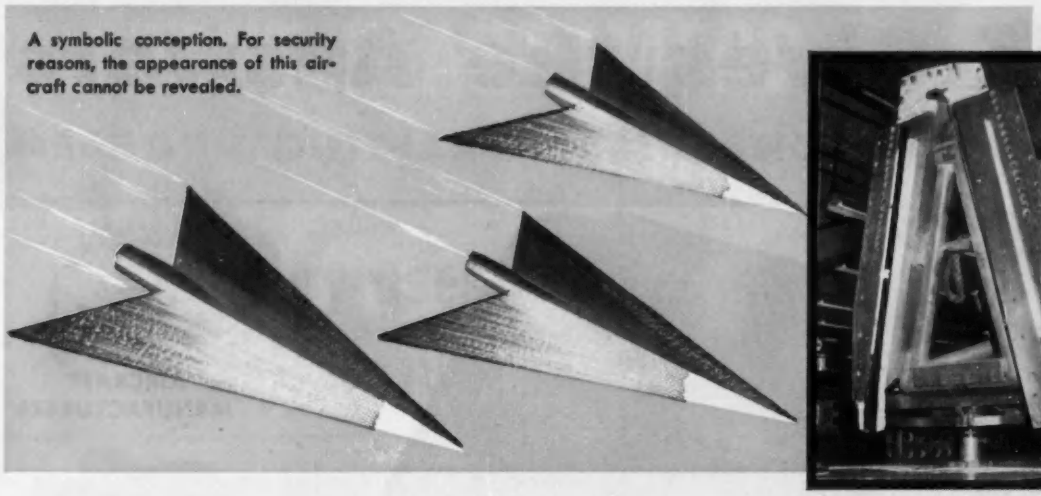
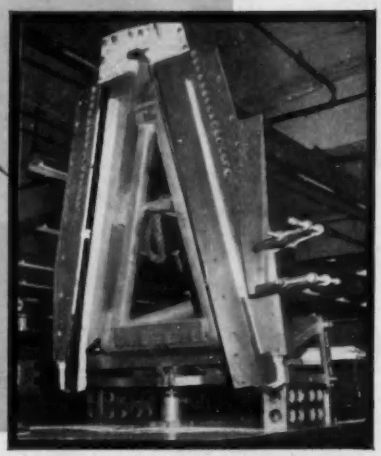


A symbolic conception. For security reasons, the appearance of this aircraft cannot be revealed.



A master drill and setting gauge, showing use of Epon resins to duplicate compound curves and contours.

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dies, tools, jigs, molds and fixtures

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- Adaptability to repairs and design changes.
- Minimum finishing requirements for smooth surfaces.

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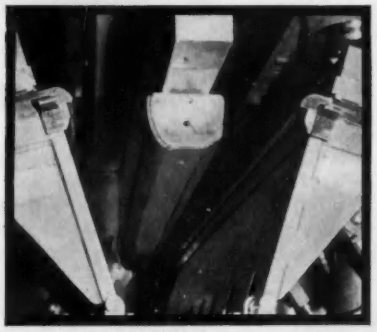

Stretch die, with Epon resin facing of involved contours, ready for run on 800-ton press.

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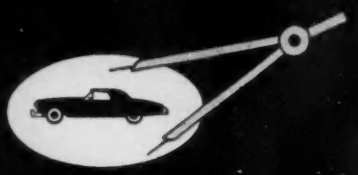

in design

Mercury uses 5 neoprene components in 1957 heater-defroster

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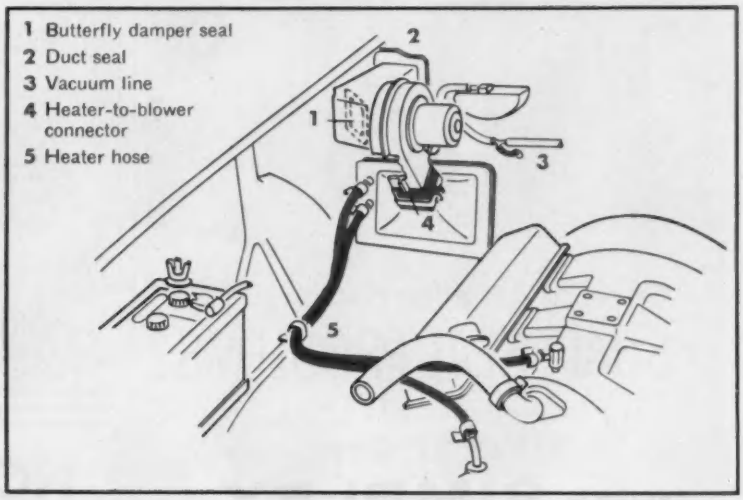

In all its forms neoprene resists ozone, heat, oil

Neoprene is one of the reasons why the heater-defroster system in the 1957 Mercury is effective, dependable. Neoprene is used in the following components: (1) The fresh-air intake butterfly damper seal is die-cut from sheet neoprene. (2) Duct seals in the Mercury system are closed-cell sponge neoprene to give airtight, low-pressure seals on the ducts. (3) The vacuum line is extruded tubing. (4) The heater-to-blower connector is dipped latex neoprene. (5) The heater hose tube and cover are also made of neoprene.

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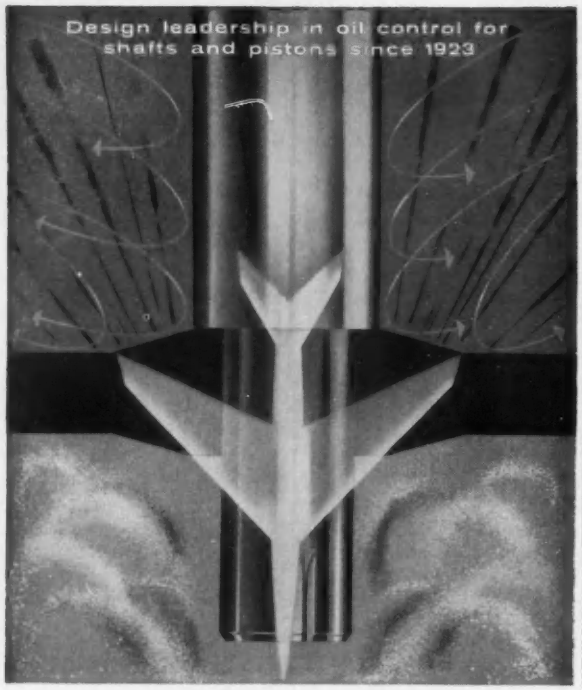

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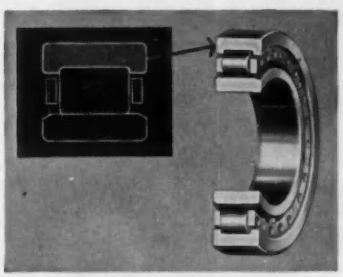

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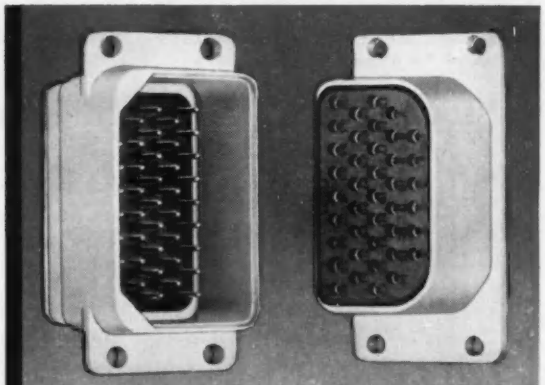

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(ac) puts the (ac) cent on

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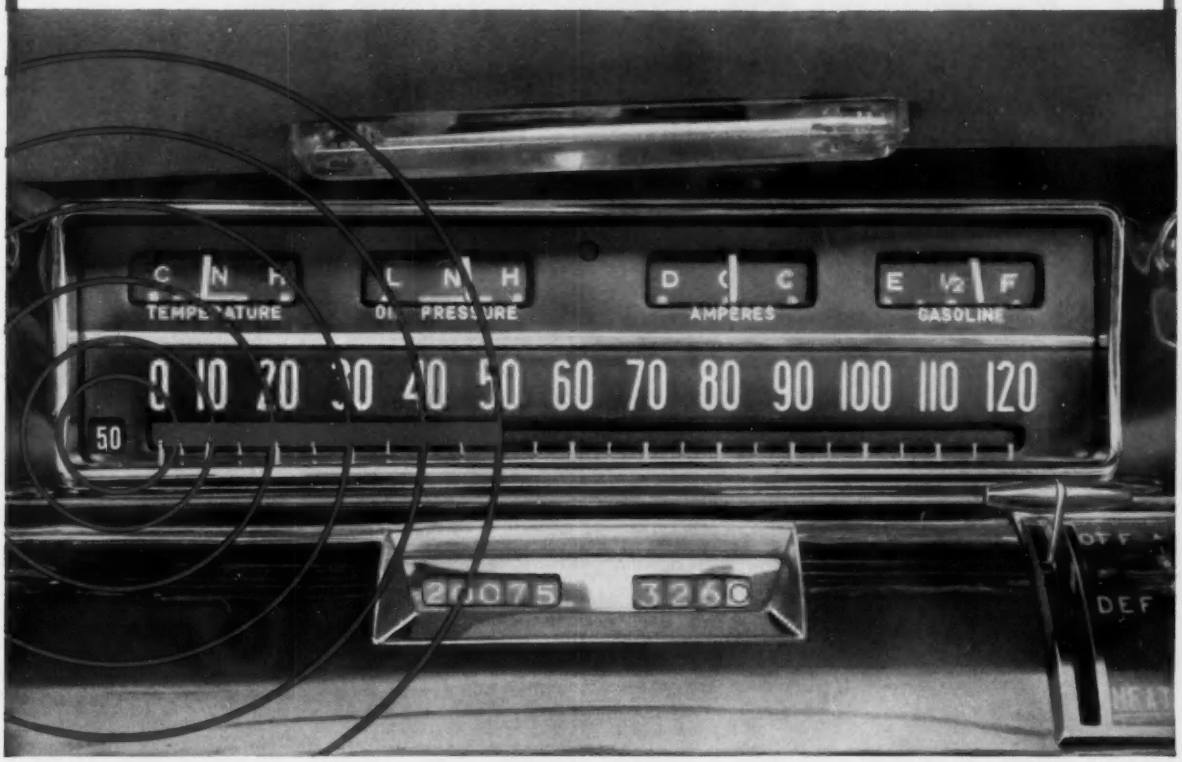
How AC's new automatic speed control grew out of common shop talk.



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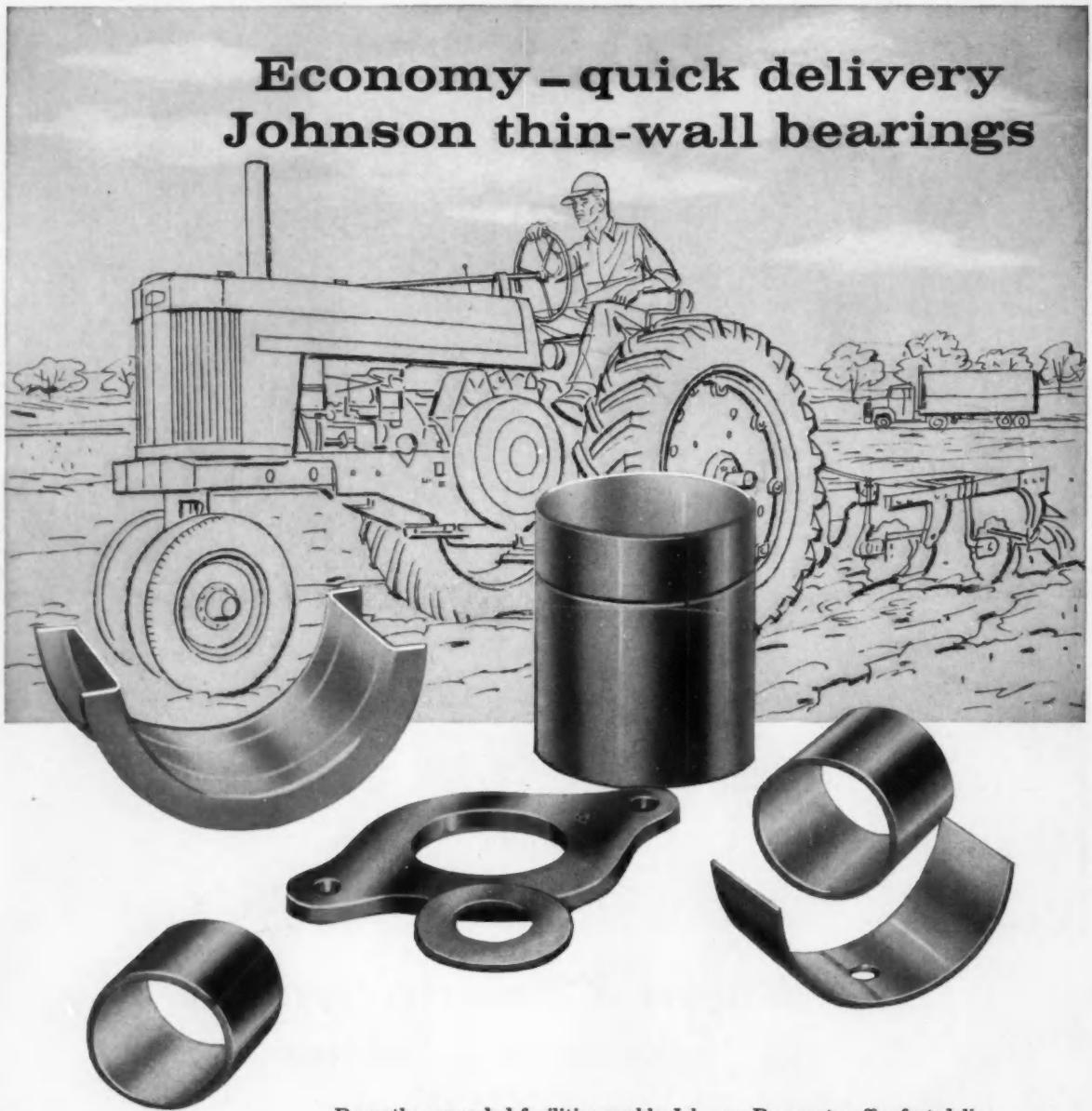
Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL

Economy – quick delivery Johnson thin-wall bearings



Recently expanded facilities enable Johnson Bronze to offer fast delivery on all types of economical thin-wall bearings. Made by bonding bronze powder or copper-lead powder to strip steel, these bearings can be machined to any tolerance in plain, flanged and half-bearing types. Also available are stamped plates, washers and other flat bearing surfaces.

Thin-wall bearings are very economical in large quantities, and are ideal for any mass-produced products. If you would like to investigate the cost-saving possibilities of Johnson thin-wall bearings, our representative will be glad to give you full information.

JOHNSON Bearings

Johnson Bronze

675 S. Mill Street, New Castle, Pa.

TORQMATIC shifts at full throttle– eases haulers out of muck and mire

THE TERRAIN is rough. Some of the grades are 15% or more. You're hauling 50-60 tons.

So you need TORQMATIC DRIVE.

You need TORQMATIC because it quick shifts at full throttle. No lags or stalls between gears. You need TORQMATIC to eliminate the gearshift guesswork of clash box transmissions. TORQMATIC not only eliminates guesswork – it can increase engine life 47%!

You need TORQMATIC to get loaded haulers out of soft mud and mire quickly without towing.

You need safety, too, the kind of downhill safety TORQMATIC provides with its optional hydraulic retarder. You just pull a lever for slow descents *without riding the service brakes.*

Take a tip from 55 manufacturers of 122 different kinds of road-building and construction equipment. Get the Allison TORQMATIC story.

Ask your equipment dealer or write: Allison Division of General Motors, Box 894X, Indianapolis 6, Ind.

NO. 2 IN A SERIES ON SPEEDING AMERICA'S ROAD-BUILDING PROGRAM

GM TORQMATIC

Allison

TORQMATIC DRIVES

For tricky shapes like these...

Steel that's hard and tough but easy to machine

PARTS like slitter knives, collets, split bearing races and the others shown above have to be hard and tough. But because of their intricate shapes, they have to be made of a steel that's easy to machine. This combination of toughness and machinability isn't easy to find. But you get it in Timken® 52100 steel.

Timken 52100 steel has a fully spheroidized structure that makes machining easy—without sacrificing strength or hardenability. It is a high-carbon analysis alloy steel with high fatigue and tensile strength and good hardenability throughout its cross section. Timken 52100 steel withstands working pressures up to 200,000 p.s.i., can be oil quenched to a maximum hardness of 65/66 Rockwell C in normal sections. And you can be sure of uniform quality in every shipment of Timken 52100 steel, because the Timken Company controls quality through every production step, from furnace to final inspection.

The Timken Company pioneered the production of 52100 steel tubing in the U. S. We're one of the world's largest producers of this hard, tough steel and the *only* source of 52100 steel in three finished forms—bars, tubing and wire. For small run or emergency requirements, we maintain a mill stock of 52100 tubing, in 101 sizes ranging from 1″ to 10½″ O.D. Write for a complete stock list of available sizes, grades and finishes. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING